JULY 27, 1951

THE ENGINEER

A Seven-Day Journal

Coal Utilisation Joint Council Report

IN its annual report for 1950, which has just been published, the Coal Utilisation Joint Council states that the present situation gives considerable point to the two-fold aim of the council, which is to secure the most efficient use of solid fuel in the home and to encourage the best use of fuel in the interest of the individual and the nation. It is contended that electricity load shedding and the dislocation of industry, as well as the difficulty of keeping up gas production, would have been largely avoided if solid fuel had been used for domestic space and water heating. The council, it is stated, would need a quarter of a million pounds to carry out its plans to promote on a national scale the better use of fuel in homes and the National Coal Board has agreed to contribute three-fifths of this sum. With these increased funds it will be possible to start a nation-wide campaign to stimulate the coal and appliance trades to give first-class service to the public, provide training for sales and service staffs of the appliance industries, and publicise the use of solid fuel in modern appliances. In addition to the information centre opened at Manchester other centres are to be set up in Cardiff, Bristol and Leeds and others are being sought in Nottingham, Birmingham, Newcastle and Cambridge. On the subject of smokeless zones the Council states that, whilst it supports the smoke abatement campaign, a note of warning should be sounded lest this movement should outrun the supply of suitable fuel. Of the annual domestic consumption of 35 million tons of solid fuel only 6 million tons were at present smokeless fuel. The production of such smokeless fuel was unlikely ever to increase sufficiently to enable the replacement of the bituminous coal at present used. For this reason the council believed that the only practicable solution to the problem was the progressive development of appliances capable of burning bituminous coal with less smoke.

Productivity Team's Report on Mechanical Handling

THE report of the specialist team of the Anglo-American Council on Productivity on long-distance freight handling has just been issued. In this report it is pointed out that the vast scale of transport operations and the high level of wages in the United States considerably increases the scope for the use of mechanical equipment and of road and rail vehicles of large capacity. In methods of freight handling no outstanding difference in the standard of achievement in the two countries was apparent, but there were important variations in American technique and in the attitude of mind towards mechanisation, and in the degree to which particular methods common to both countries have found favour in one more than the other. Factors that encourage the use of mechanical equipment in the United States are the larger average consignments and the greater potential saving in labour costs due to the high wage rates. Unlike Great Britain, where it has become the common practice in freight handling to remunerate labour on a piecework basis, American labour engaged in transport industries is normally paid on a time basis. This applies with special force in American docks where labour is paid at hourly rates, its management being similar to that in Britain before decasualisation in 1941. In the recommendations of the report particular emphasis is laid upon the potentialities in general transport for fork-truck operation, either with pallets or specialised attachments, and on the development of palletisation and the unit load for transportation. In this connection it is stated that consideration should be given to the establishment of a central committee consisting of representatives of railway, road transport and dock interests, manufacturers, traders, the British Standards Institution, and the Services, in order to secure the fullest exchange of information and experience on palletisation, to pursue prospects of development and to consider issues of principle. The bodies which participated in the formation of the team should, it is considered, take the initiative in establishing such a committee. The committee's principal objective should be the stimulation of the development of palletisation.

Annual Report of PERA Council

ON Thursday, July 19th, the Council of the Production Engineering Research Association of Great Britain presented its report to the annual general meeting of the Association. This report stated that, in addition to the technical committees dealing with investigations in the fields of metal forming and metal cutting, two new committees had now been constituted to control investigations on machine tools and surface finish. The technical committee on metal forming, in order to sub-divide its wide field of interests, had set up three new subcommittees to control investigations on its behalf in connection with impact extrusion, wire drawing and thread rolling. Dealing with staff matters, it was stated that additional income received during 1950 from new members had largely been used for the engagement of new staff to enable the field of research to be widened and technical inquiries to be handled as expeditiously as possible. More than 8000 hours of unpaid overtime had been worked voluntarily by members of the staff during the year. Some ten items of equipment valued at about £6500 had been purchased under the special Department of Scientific and Industrial Research grant. A number of other items of equipment for the research department were approved for purchase from revenue by Council, following recommendations from the Technical Policy Committee. In addition, over seventy items of equipment for use in research investigations were designed and manufactured by the Association. Brief particulars were given of thirteen general investigations in hand, and it was stated that programmes for five new investigations had been compiled and the manufacture of equipment begun for them.

New Gas Council Research Centre

THE Gas Council has set up a second research centre at the Nechells Gasworks, Birmingham, and at this centre the work will be mainly concerned with the complete gasification of coal. The centre will be administered by the West Midlands Gas Board on behalf of the Gas Council, and its director will be Dr. F. J. Dent, the present assistant director of the Gas Research Board. The establishment of this centre follows upon the announcement in September last that the Gas Council had set up a research committee, under the chairmanship of the chairman of the Gas Council, Sir Edgar Sylvester. At that time it was stated that the existing laboratories of the North Thames Gas Board were to be the nucleus of the Gas Council's London research station. Earlier this year the chairman of the Gas Research Board, Colonel Harold C. Smith, referred to the fact that one of the major duties placed upon the Gas Council under the Gas Act was the organisation and development of research, and he then pointed out that a comprehensive programme had been completed and submitted to the Minister of Fuel and Power for approval. Dr. Dent has been closely concerned with the experiments upon complete gasification which have been conducted at the Poole Research Station. Owing to the great importance it attaches to this particular field the Gas Council decided that the work could be accelerated at Birmingham, where there are far greater facilities than at Poole.

Lloyd's Register Shipbuilding Returns

THE Lloyd's Register shipbuilding returns of merchant ships of 100 gross tons and over for the quarter ended June 30, 1951, has just been published. It shows that in Great Britain and Northern Ireland the steam and motorships under construction at the end of June numbered 345, of 2,114,319 tons gross, an increase of 41,596 tons on the previous quarter. Of those vessels, 95, of 552,129 tons, were fitting out afloat and 250, of 1,562,190 tons, were still to be launched. During the quarter 79 ships, totalling 382,478 tons, were commenced, 79, of 414,138 tons were launched, and 70, of 346,211 tons were completed. On five vessels of 1350 tons work was suspended. The tonnage under construction for registration abroad or for sale amounted to 105 vessels, of 729,313 tons, and of these 23, of 139,264 tons, were commenced during the quarter. Oil tankers represented more than half of the tonnage under construction in the country. The vessels under construction abroad totalled 869, of 3,216,900 tons, and of this tonnage, some 781,400 tons was intended for registration elsewhere than in the country of construction, or for sale. A world summary shows that, of 1214 vessels of 5,331,200 tons gross under construction in the world at the end of the quarter, 39·7 per cent was being built in this country. The largest ship mentioned in the returns is the "United States," of 51,500 tons, launched in the U.S.A. Other large vessels under construction in the world included seven steam and six motorships between 20,000 and 30,000 tons each, and twenty steam and twenty-three motorships, each between 15,000 and 20,000 tons.

Air Registration Board

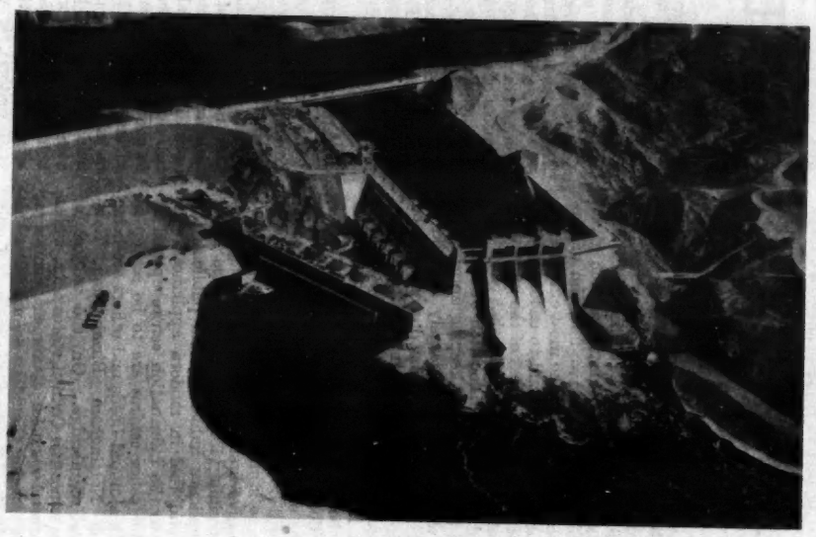
THE fourteenth annual report of the Air Registration Board for the year ended March 31, 1951, has now been published. The report which was presented by the Chairman of the Board, Lord Brabazon of Tara, mentioned the many new technical problems and their effect on airworthiness considerations, which had arisen directly from the employment of jet and turbo-jet propulsion for aircraft. Referring to the trend of airworthiness, the report states that the Ministry of Civil Aviation and the Board were aiming to devise a framework in which the airworthiness of a machine be considered in relation to the operational requirements of a particular flight; and in this way to match the aircraft with the operation without stipulating a performance which in some respects might be higher than necessary on some occasions, and yet for other occasions inadequate. The report emphasised the usefulness of extensive flight testing of new components before their adoption and mentioned that the lack of airworthiness was fortunately not often the cause of air accidents. In the new issue of Section D of British Civil Aviation Requirements attention was now focused on such new design details as the windows in pressurised aircraft, crash protection and the employment of integral fuel tanks. Elsewhere in the report is an account of the certification of power plants and other aircraft equipment.

STAGES IN THE CONSTRUCTION OF THE DAVIS DAM

DEWATERING AND FILLING OF CUT OFF TRENCH, OCTOBER 1948

COMPLETED DAM EMBANKMENT, JUNE 1949

CONCRETE STRUCTURES APPROACHING COMPLETION, OCTOBER 1950



START OF POWER GENERATION, JANUARY 1951

The Davis Dam Project, U.S.A.

No. II—(*Continued from page 76, July 20th*)

Sequence of Construction

Construction of the dam and its major appurtenant structures took place in accordance with the following general sequence.

(1) Excavation of the diversion channel and the forebay and spillway channel through the left rock abutment.

(2) Excavation for the spillway, the intake structure and part of the power station.

(3) Placing of concrete in the forebay channel and grouting of the spillway and the intake structure.

(4) Construction of the spillway and the intake structure.

(5) Diversion of the river.

(6) Excavation and dewatering of the dam cut-off trench.

(7) Placing and compacting of the dam embankment.

(8) Construction of the power station.

(9) Closing of temporary diversion openings in the spillway structure.

(10) Installation of power plant.

Various stages in the progress of construction are shown in the accompanying illustrations. The construction of Davis dam and its auxiliary works presents several points of interest, which are discussed in detail in the following pages.

River Diversion

Diversion of the Colorado River at the dam site took place during a fifty-six-hour period from June 26 to 28, 1948. While at Hoover dam and again at Parker dam, the Colorado River had been diverted through temporary diversion tunnels, the Davis dam river diversion was the first operation of this kind on the Colorado River to involve the construction of a channel by-passing the entire dam site. At a position approximately 800ft upstream from the centre line of the dam, a slotted timber trestle over the main river had been constructed and prior to the commencing of the diversion two quarries had been prepared, one on the Arizona and one on the Nevada side of the river. Operations were started in the early morning of June 26, with a fleet of twenty bottom-dump lorries being loaded at one quarry, dumping their charge while crossing the river, again being loaded at the other quarry and dumping once more on the return journey. Each of the lorries had a capacity of 13 cubic yards, and in order to permit the use of rock of up to 3ft maximum size, a 3ft 6in central slot had been provided along the trestle. During the diversion, the rate of flow of the river varied between 12,000 and 18,000 cusecs. It had been hoped that uniform dumping across the entire width of the trestle would lead to a gradual diversion at almost 90 degrees into the diversion channel, and, indeed, by the evening of June 27th, the cofferdam proved effective, with the exception of a 40ft wide channel near the centre. Here the prevailing current became so strong that even the largest available rocks were carried away. Almost the entire second night of the operation was spent in an unsuccessful effort to close the remaining gap by further dumping. In the morning of June 28th, the contractor decided to adopt emergency measures and placed long framework girders of structural scrap steel across the gap on the upstream side of the trestle. A ramp was constructed leading to the gap at about river level and end-dump lorries were driven along the ramp one at a time and were made to discharge large rocks against the scrap steel framework. Prevented by the steel members from being swept away, the rocks thus placed contributed to an eventual reduction in the remaining gap, which, in turn, slowed down the current at the site. Finally, bottom-dump lorries operating from the trestle, in co-operation with end-dump lorries working from the ramp, succeeded in closing the entire channel. Altogether, approximately 29,000 cubic yards of rock were placed during the fifty-six-hour period, and it has been estimated that about 30 per cent of this was carried downstream by the current. After the closure had been completed, the trestle was dismantled and the cofferdam was covered with impervious material, in an effort to prevent seepage into the dam site.

Together, the diversion and forebay channels form a canal about ⅔ mile long, encircling the left abutment of the dam. At the time of the river diversion, the spillway and the power plant intake structure had been built up above Elevation 550, thus permitting a 50ft depth in the channel during the diversion period. A number of openings left in the spillway structure facilitated the flow of the diverted river.

Upstream View prior to Diversion of River, April 1948

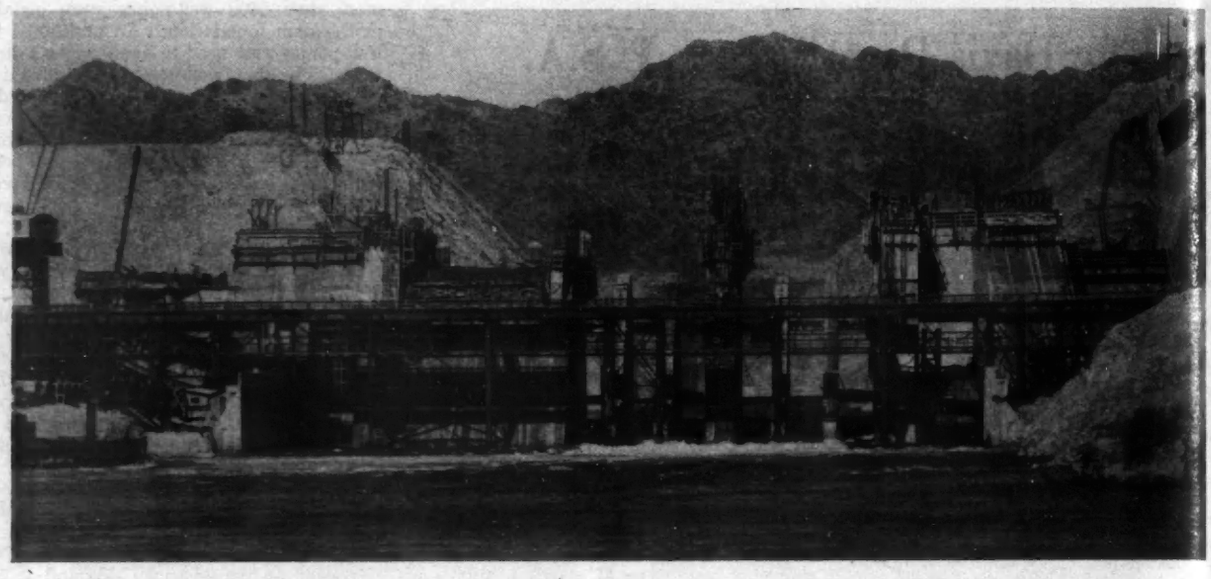
Dam Construction

All construction work on the dam proper, from the diversion of the river to the completion of the embankment fill, was executed in the remarkably short period of only ten months. The contractor actually set a record for Bureau of Reclamation projects by placing 730,000 cubic yards of fill in one thirty-day period. The first step after the diversion of the river was the dewatering of the area inside the cofferdams. One set of four 10in pumps operated from the downstream cofferdam and a second set of eight pumps was placed on a wooden barge to operate in the deepest section between cofferdams. The first set pumped for 110 hours and the second one for seventy-two hours, pumping out about 600 acre-feet of water. Immediately following this operation, the installation of well-points began. In all more than 2400 well-points were installed in the dam foundation. An additional 900 well-points were used to dewater the tailrace area. The first well-points were placed on the downstream toe of the main cofferdam to stop seepage. Then, as the cut-off trench excavation proceeded, additional well-points were installed. Most of the well-points were sunk by the sand casing method involving the jetting down of a casing, the inserting of the well-point and sand, and, finally, the removal of the casing. In some areas where clay was encountered these casings were driven by a steam hammer.

To service the well-points in the cut-off trench excavation there were twenty-two 10in pumps and five 8in pumps, with a total pumping capacity in excess of 50,000 gallons per minute. However, all well-points were not drawing fully at all times, so that the maximum pumping rate was approximately 10,000 gallons per minute. Water was pumped from each of the well-point headers to main headers situated on each side of the cut-off trench excavation. These 24in and 30in pipe-lines were situated at a 508ft elevation on the upstream side and at 501ft on the downstream side, and were joined by a 36in pipe which led through the upstream cofferdam. The highest point in the discharge line was at an elevation of 548ft, with the discharge at an elevation of 535ft. Thus, water was lifted from below the bottom of the cut-off trench through almost 100ft.

Even with all these dewatering facilities, it was not possible to dry the cut-off trench completely. Since the trench was 120ft wide at the bottom and the well-point headers were situated along each side, it was not feasible for the pumps to draw water from the centre of the trench. To remedy this situation, a trench was dug along the centre line of the excavation and a French drain was installed. This consisted of a 16in pipe with ¼in by 6in slots cut out. The pipe was backfilled with 1½in to 2½in gravel, and was serviced by two 10in pumps, with two 8in pumps standing by for emergency service. Similar French drains, of 6in pipe, were installed on the side slopes just downstream from the centre line of the concrete cut-off walls which were constructed along both the Arizona and the Nevada abutments, but not across the bottom of the cut-off trench. Connected to the drain at 50ft intervals were 2in grout pipes, running up the side

Concrete Structures Approaching Completion, October 1950 Start of Power Generation, January 1951



DOWNSTREAM VIEW AFTER DIVERSION OF RIVER, AUGUST 1948

slopes to the top of the cut-off trench excavation. After fill had been placed to this level, these pipes were used to grout the drain, grout completely filling the pipe and flowing into the voids in the surrounding gravel. A special grout mixture of one sack of "bentonite" to three sacks of cement to 9½ cubic feet of sand, to 10 cubic feet of water was used. Bentonite, an aluminium silicate, has the property of swelling when mixed with water, absorbing as much as five times its own weight in water.

The major problem in placing the impervious dam fill was the establishing of the appropriate water content. Engineers of the Bureau of Reclamation estimated that, to obtain the maximum practical density with the material at hand, the moisture content should be 12 per cent by weight. The contractor at first tried wetting the fill material by installing a large sprinkler system at the borrow area 3½ miles from the dam. This process involved the construction of a 2-mile-long, 8in pipe with pumps capable of raising 400 gallons per minute 500ft in elevation. By sprinkling an area of 2 acres for about five days with this water, the contractor hoped to wet the borrow material to the full depth of a cut (about 20ft). However, this system proved unsuccessful because the water did not penetrate the undisturbed material more than 1ft or 2ft. As an alternative, the contractor stationed a man with a fire hose on the top of the cut to wet the borrow material just before and as it was being loaded into the earth-moving vehicles. Additional moisture at the fill area was provided by three large tank lorries.

Once the proper moisture content had been obtained, compaction was accomplished by sheeps-foot rollers which had been built to Bureau of Reclamation standards. Twelve passes by these rollers were found to compact the 8in layers to a 6in thickness at the maximum practical density. The semi-pervious material was laid in 14in layers and, after sprinkling was compacted to 12in layers by eight passes of the rollers. This material had been obtained in the process of the forebay and diversion channel construction, had been screened to a 4in maximum size, and had been stockpiled for fill purposes. The rock-fill material (Zone 3) was dumped in 2ft to 3ft layers and was levelled by bulldozer-equipped tractors. The material available locally for riprap purposes was found to be badly jointed and broke up easily. It was therefore necessary to develop a borrow area 7 miles downstream where a fine-grained igneous rock was found.

To check the fill material density, field tests were made for comparison with the laboratory standards. This test involved a unit dry weight determination for the compacted fill material. The laboratory standard of the Bureau of Reclamation is a modified Proctor test in which the 5·5 lb hammer is dropped 18in instead of 12in. The borrow material varied to a certain extent, but the average optimum moisture content was 12 per cent. Because of the high unit pressure exerted by the heavy rollers, the optimum moisture content for twelve roller passes was found to be about 1 per cent lower than the laboratory optimum. Thus, the field moisture was held from 1 to 2 per cent below the laboratory optimum to attain maximum field density and to stop any excessive pore pressures. The needle moisture tests were used in the field prior to rolling of a new lift. Needle density tests were made at about 50ft. centres immediately after compaction. Whenever the latter test indicated probable low fill density, a field density test was made.

To measure the pore pressure in the dam at various points, sixty-five piezometers were installed. These piezometers had a 1in diameter round plastic head in which a small porous stone was placed. The heads were attached to two ¼in diameter plastic tubes. A set of two such tubes ran from each piezometer to a well situated at the downstream toe of the dam. In this terminal well were placed gauges to indicate the pressure at each one of the piezometers.

(To be continued)

International Conference of Naval Architects and Marine Engineers

No. IV—*(Continued from page 83, July 20th)*

THE first paper presented on Thursday afternoon, June 28th, was:

PROPOSED DESIGN OF A COMBINED RESEARCH, TRAINING AND CARGO SHIP

By Professor Ir. H. E. JAEGER and Ir. J. C. ARKENBOUT SCHOKKER

SYNOPSIS

The main purpose of the design is reviewed, that is, the need for boys to learn the job, especially the use of complicated modern navigation instruments, and the necessity for the ship to earn her own living by carrying cargo. Reference is made to the strength of ships and the more important experiments are listed. The principal dimensions, speed and horse-power of the proposed ship are tabulated and the deciding factors given. Machinery installations are briefly discussed and also the position selected for the engine-room. There is a review of general arrangement plans, including a note upon subdivision, the provision of access to the structure for stress measurements and the inclusion amidships of ballast tanks, anti-rolling tanks and a "Denny-Brown" stabiliser.

For the investigation of different constructions the fore part of the vessel is framed longitudinally and the after part transversely, while the bulkheads have varying stiffening systems. The programme of strength investigations is considered and possible weight distributions suggested, while the influence of heaving can be examined and experiments on torque carried out. Installations for taking measurements and the working of the ship are briefly commented upon.

DISCUSSION

Mr. James Turnbull (Great Britain): The authors suggest that the maritime nations should build similar ships and collaborate in research, and I feel that that is touching on a major question of policy which is not one for technical institutions, but rather for the industry's research organisations. To some extent this design defeats its object by the fact that it is a specialised design and is not of the normal commercial kind. It has various transverse and longitudinal bulkheads at the 'midship area which makes it difficult to assess the actual modulus of the section, and transverse stiffening at one end and longitudinal at the other makes it difficult when considering deflections.

The Admiralty Ship Welding Committee found that instrumentation was the key to a complete understanding of the stresses in ships in a seaway. The "Ocean Vulcan"

was sent to sea and measurements were taken of the forces acting in the ship; then the ship was placed in still water and the endeavour was made to reproduce those stresses. The experimenters were able to put on many more instruments in still water and to obtain better results in that way, and I feel that it is by this means that future developments in structural research on ships will take place.

Already in this country we have an indication of these developments, because since the early experiments on the "Ocean Vulcan" we have placed on board, by the good graces of the British shipowner, a statistical strain gauge which has recorded the range of stresses and the number of times that range is reached during one complete year of service. The ship went to various parts of the world, mainly the North Atlantic, and in order to avoid delay in the publication of the figures I will make them known.

Range of stress, hog to sag	No. of times
1 ton per square inch	266,884
2 tons per square inch	7,105
3 tons per square inch	1,309
4 tons per square inch	102
5 tons per square inch	5
6 tons per square inch	2

The figures are very interesting. By this method we are able to apply the instruments to and, obtain results for all lengths of ships, all coefficients of fineness, various length/depth ratios, various speeds, forms of construction, and other factors, and we might even introduce quality of workmanship. The ship put forward is a comparatively deep one, and I think we should get more valuable information from a shallower ship.

I notice that they propose to put the ship into heavy weather conditions and to load her very severely. The authors rather indicate that Lloyd's Register has already approved the scantlings of the proposed ship. But if this design had been submitted to Lloyd's Register, the very fact that it was abnormal in character would have led to investigation of the distribution of the weights, and the ordinary scantlings as published in the Rules would have been added to because of this rather bad distribution of load.

I would emphasise that these are only nominal stresses, and far too many people think that these nominal stresses are actual stresses. You will see from the figures I have given that the figures we are getting on ships at sea are much lower than the nominal stresses.

The Admiralty Ship Welding Committee has got six reports of tests carried out at sea; I expect three of them will be published before the end of the present year, and the remaining three will be published before the end of 1952. I feel that all the suggestions made in the paper are covered by these reports and that nothing further should be done until these reports are studied.

Capt. W. H. Coombs (Great Britain): It is inevitable that the authors, in setting forth their case for a combined research, training and cargo ship, should touch on the relative merits of sail training and modern steam training. But I feel they have dismissed sailing ship training far too lightly by describing it as a system which gave some idea of the hardships of life at sea and, at the same time, made the cadets proficient in the working of sails and ropes. The enthusiasts of sail training believe that it did far more.

To combine a modern navigators' and seamen's training accommodation in a research ship is quite a practicable suggestion, but I doubt that it is possible to combine a research ship with a vessel intended to operate commercially as a cargo ship. I fear that in practice the idea of a combined research and cargo ship will not commend itself to those concerned with the carriage of goods by sea or, indeed, with the insurance of those goods.

It is stated that international collaboration might be necessary to make the authors' project possible, and I would say that the possibility of international financing of the scheme is remote.

Professor A. M. Robb (Great Britain): The difficulty presented by attempting to marry two forms of construction has already been mentioned.

It is suggested that diesel-electric machinery should be used; there you have the one type of propelling engine in which you can most accurately determine the input to the propeller, yet there is no mention of any thrust measurement.

Concerning the general question, as I see it, in all branches of naval architecture we have recently a much wider range of information; but have not correspondingly deepened our understanding, and in effect our powers of analysis have been completely overwhelmed by the body of information we have.

Viscount Runciman (Great Britain): It is obvious that a ship of this design will not be cheap to build. She will cost nearly £1,000,000 and a rough calculation suggests that she might cost more than £60,000 a year to keep in being. I feel bound to say that her value from the research point of view would have to be extremely high to justify this expenditure in the eyes of commercial operators, whether working individually or through associations, or indeed in the eyes of Government, who would have to raise the money by taxation. I think it would be impossible in practice to get any noticeable contribution to the running cost from commercial operations, and I should be sorry to be in the position of a ship manager who had to face the worries of the bills of lading for a cargo which was specially directed into storms in a ship whose captain was under the orders of a research staff. We might get over that difficulty if a Government was willing to use such a vessel for the carriage of Government stores, so that the commercial considerations of insurance and finance, and the legal considerations, could be avoided. But that would mean abandoning the idea of running such a ship on an international basis.

I feel that such a ship will have to be considered simply as a research and training ship and that any cargo she carries will have to be in the form of ballast.

The Chairman, Dr. S. F. Dorey (Great Britain): I would make the comment, which may be of interest to shipowners and superintending engineers, that if occasionally, when ordering new ships, they would have a hole of about 2in diameter put right through the screw shaft, it would help a great deal in the measuring of stresses that occur, not only in the shaft itself, but also in the propeller. The stresses in the propeller, of course, will be affected to some extent by the rudder, the shape of the rudder, the stern post and, in particular, the aperture clearance. It is possible to fit strain gauges on the blades of the propeller and, by means of a hole in the screw shaft, to bring the leads right through to the coupling end of the shaft, and then we could take the measurements we require. Arrangements have been made for that to be done in one particular ship, but it means that the hole has to be made by withdrawing the tailshaft, whereas if that was done at the start we could very quickly find the effect of the aperture clearance and also the effect of the shape of the aperture itself on the propeller from the point of view of vibration and singing phenomena and the like.

The concluding paper of the London proceedings, given on Thursday afternoon, was entitled:

SOME ASPECTS OF PREFABRICATION IN SHIP CONSTRUCTION

By N. G. Eckersom

Synopsis

The arguments for and against prefabrication have often been discussed. The fact that prefabrication has been accepted so rapidly, in spite of the necessary heavy capital outlay and the radical change in general lay-out involved, may be the best evidence of the advantages this method offers.

The building of hulls in prefabricated units has, however, introduced new problems and accentuated old ones. The author deals with some of the aspects that have arisen at the shipyard of Messrs. Eriksbergs Mek. Verkstads Aktiebolag, of Gothenburg, where the prefabrication system has been used since 1936. After a brief description of the modernised hull production department of the yard, the author discusses at some length the area required for this new type of production and deals especially with the assembly area and the units storage area.

The assembly area comprises actually three separate areas, namely:

I. For simple unit assemblies, for example, built-up girders, webs, &c., with their weights seldom exceeding 5 to 10 tons.

II. For assembling main units, usually panel-shaped, comprising plates stiffened by plain rolled sections and/or simple units as described in I above.

III. For compound units comprising plates, sections and units as described in I and II above.

The necessity for a well-controlled flow of steel through the platers' shop, beginning at the steel stockyard, are dealt with. It will be shown that the assembly area becomes the keypoint of the production line and that the detailed planning of it is of major importance.

The problems that have arisen in connection with handling and storing of the big hull units are dealt with. Also some opinions on cranes are discussed, as well as suggestions for drawing-office work and the introduction of modified material marking and unit symbols.

In times of labour shortage the method offers certain advantages from a training point of view.

With the reading of the paper the author exhibited a cinematograph film entitled "The Birth of a Ship," which illustrated prefabricated construction in the Eriksberg shipyard.

Discussion

Sir Amos L. Ayre (Great Britain): May I say how interested all the shipbuilders have been to see this film, because in recent years the shipbuilders of the various European countries have got much closer together than formerly in all matters of this sort. It was also interesting to see how well a difficult site was worked out, as shipbuilders always like a nice big rectangle or a square.

The (E) berth seems rather pinched for storage space. If the desire is to reduce the berth cycle, as in this case, to three months, storage space becomes very important, and I would say that for a monthly cycle it should be probably equal to the length of the ship.

In the United Kingdom, twenty-five years ago, there were many instances of hydraulic riveting, extending to 34 per cent of the hull. That amount of hydraulic riveting meant a large amount of prefabrication and was the beginning of the system.

In our two yards in the United States we often considered whether, if there were two cranes on a berth, one would get in the way of the other, and I would ask the author what his experience has been in operating two cranes on the same track.

A very important point for the consideration of shipbuilders in laying out yards of this type is the heavy capital outlay, which is very closely allied to the average output. It is all very well, when there is a large number of ships to build, but in times of depression or even average conditions one can spend too much money in the capital sense. Depreciation allowances largely determine this, and I understand that in Sweden a maternal Government gives very fine allow-

ances by way of depreciation; I gather that it is possible to do a lot of this work and more or less automatically write it off out of current profits. Here we are allowed only a few per cent per annum.

I have sent to the Institution, for their records, an album of photographs which Mr. Kayser gave me in America, relating particularly to the Kayser Incorporated yard in the State of Washington, which is, I think, probably the finest yard the world has seen. I suggest Mr. Eckerbom might find time to look at this.

Mr. J. A. Milne (Great Britain): I am envious of Mr. Eckerbom's storage space, for the only way in which most of our yards can expand is skywards.

For plates and other things he has adopted vertical storage, which we find more suitable than horizontal on account of corrosion and considerations of access.

I am surprised that the Eriksberg shipyards use alternating current in the welding shops and direct current on the berth. It would appear to be more economical to use alternating current throughout. We have done away with most of the welding skids by incorporating channels in the shop floor, and find no difficulty in welding outside with alternating current.

Having seen the film, I am getting worried about the use of heavy cranes and wonder whether we have not gone to the extreme in trying to provide heavy lifts, losing a lot of time and money in so doing. My experience has been that shipwright's costs in the handling of plates and sections for small ships is high, on medium ships it is low, and on heavier ships the curve begins to rise again, and I should hate to think that welding technique will lead to lifts of 100 tons, with all the difficulties associated with cranes.

The author mentions three-dimensional units, but does not make much reference to drawing-office work in that connection. Does he issue a plan of decks and bulkheads, or does he issue three-dimensional drawings of sections of the ships?

I should like to hear more about semi-skilled labour, and whether there is an increase or otherwise in the employment of unskilled labour.

Mr. J. Lenaghan (Great Britain): The author has referred to cold and hot bending, and I would like to ask what he means by cold bending. I am impressed by the fact that in Scandinavia and other places abroad they can use the spaces under the berths for storage. Is that merely to avoid taking in further ground for small stores? I always wonder how modern shipbuilding compared with the older methods in respect of the number of men employed and whether the author finds that the output per man has been altered considerably. Although the film indicates the building of tankers and cargo liners, would the author stick to the twenty-two-week period if the programme were made up of all types of vessels?

It seems that a good deal is left to foremen. I do not disagree with that, but am sure our production planners would say that the shop load should be just as carefully planned as the berth load. Again, in connection with the measuring of the amount of work for one ship in "block days," the author almost suggests that past records are used as a basis. Has there been any time and motion study in connection with this block planning?

A matter which merits considerable thought, particularly in connection with prefabrication of large units, is the desirability of positioning the lifting spots, i.e., working out the centres of gravity so that things can be lifted and turned easily.

The author suggests building from the engine-room, working forward and aft. We are ahead of him there, because in one yard in this country we are building from the stern and it is hoped that, when the bow section is put on, they will launch the following day.

I am not so pessimistic as the author with regard to the effect of mechanisation on recruitment. He suggests that as we mechanise we drive people to the lighter industries, but I find that as we mechanise we get more recruits. But the skill may be in other directions than previously.

The reading of papers to the Conference was continued at Newcastle upon Tyne, when the proceedings were opened on Thursday morning, July 5th, at the Literary and Philosophical Society under the chairmanship of Sir Philip B. Johnson, B.A., President of the North-East Coast Institution of Engineers and Shipbuilders. The first paper presented was:

U.S. FLEET MAINTENANCE AND BATTLE-DAMAGE REPAIRS IN THE PACIFIC DURING WORLD WAR II

By Captain Ralph K. James, U.S.N.

Synopsis

The importance of shipyards and repair facilities to the merchant marine is well known to naval architects and marine engineers, and of ever greater importance are the repair and maintenance facilities of a naval force because of the complication of battle damage. The second World War found the United States Navy with inadequate repair facilities to conduct a full-scale naval war in the Western Pacific. While the shipyards of the United States were engaged in increasing the size of the Navy plans were being formulated to provide operating bases for the fleet as it advanced towards Japan. The resulting island and mobile floating bases made it possible to maintain the bulk of the ever-increasing fleet at top efficiency and permitted us to develop the preponderance of strength necessary for victory. Island bases were carved out of jungles and that on Espiritu Santo is illustrated, together with dry dock developments. Advance base sectional dry docks were evolved up to a lifting capacity of 100,000 tons, and also shipshaped floating repair docks with a lifting capacity of 4000 tons. Logistics played an important part and examples of battle damage and repairs effected are quoted in the paper. Many design lessons were learned, particularly the shock-proofing of machinery, fire fighting and prevention, and flooding control. It is doubtful whether the combined productive capacity of the United States and her Allies could have built, equipped and repaired ships in sufficient numbers to have defeated Japan if it had been necessary for the ships to return to homeland shipyards for repairs and maintenance.

Discussion

Sir Lawrence Edwards (Great Britain): The paper is indicative of the efficient planning for the maintenance and repair of the U.S. Pacific Fleet, backed by stupendous resources of labour and material. It is appropriate that the paper should have been presented in Newcastle, on the banks of the Tyne, on which river the tradition of ship repairing is deeply rooted and the volume of the facilities well known.

As one who was associated with the national organisation of ship repairs in Great Britain during the war, I confess to a feeling of real jealousy when I hear you refer to the numbers of men available for ship repairs, even at a United States advanced base in one theatre of operations. I think it is true to say that in the United Kingdom we had not so many available for the construction and maintenance of our Royal Navy and the merchant navies of ourselves and our allies as you had in the Pacific Fleet advanced bases.

In Great Britain during the war years we had through our ship repairers' hands some 19 million tons gross of American merchant shipping. Another point is where could you find these vast numbers of skilled men to carry out the repairs and to man the advanced base? As a ship repairer it is interesting to have stressed the vital part that ship repairs play in an emergency of any kind, for I often say how much more initiative is required for ship repairing than for doing the repetitive work of shipbuilding!

The author has stated that the U.S. Pacific Fleet expanded by ten times from the beginning of the war to the end of hostilities, and also that the repair facilities were necessarily extended by many times more. That is obviously necessary if we are to keep pace with maintenance in wartime, when we have not only the marine hazards, but the hazards of enemy action.

Mr. D. E. J. Offord (Great Britain): The paper refers to the importance and usefulness of the American battle damage reports and states that they were patterned on similar reports issued by the British Admiralty, and I thank Captain James for his courtesy in alluding to our work in such favourable terms.

He also refers to the improvements achieved in the shockproofing of machinery. One of the first of our British reports dealt with a ship which had suffered crippling shock damage. A concentrated study of the subject followed and it is still continuing, and very considerable advances have been made in the shock-resisting properties of machinery and equipment. Such properties are now a specification requirement for all warships, and I urge that shipbuilders and shipowners should seriously consider something similar for merchant navy ships. The requirement does not generally lead to increased weight or space, and need not lead to increased costs. In most cases all that is required is a closer attention to detail, which usually results in a more elegant design and generally a more efficient one from every point of view, and you will have better ships, less repair costs and shorter repair times.

There is one important lesson to which the author has not made specific reference: that a warship's function in wartime is to be at sea in all respects ready to fight. Any time spent in port for repairs or going to and from a port for such a purpose is waste of time, and another warship has to take her place in the war zone. Therefore the shortening of the time spent out of action virtually increases the effective size of the fleet. His entire paper indicates the vital importance of designing warships to have the maximum possible resistance to damage: if there is damage, its extent and nature should be such as to render repairs simple and expeditious. To obtain the knowledge requisite to execute such designs, research should be conducted in peacetime so that we do not have to learn of defects by the costly and often disastrous process of war damage experience. I think it is now generally recognised that research into warship design is no less important than research into weapon design.

Mr. R. Chipchase (Great Britain): The decision to send repair bases abroad over such distances and in such mass was vital to the eventual issue of the war.

We had a scheme under consideration here whereby, without skilled salvage craft and personnel, we might be able to save lame ducks by covering a breach in an emergency, and it was demonstrated very satisfactorily. We had also under consideration a system of "plastic surgery," involving the use of reinforced concrete to cover up breaches in vessels either afloat or ashore, and it would be interesting to know whether in America you envisaged anything of that sort.

Another problem was that of defouling without docking. Particularly after the fall of Singapore, when many vessels could not put

to sea, and others were too slow to maintain convoy speed. It was a difficult problem because ships vary so much in size, and we could not evolve anything either mechanical or electrical to meet the requirements without holding up items of prime importance for our fighting Services. The problem was solved. The method adopted had to be foolproof, so that it could be used by native labour, and ships were maintained in service. Hundreds of vessels were cleaned in dozens of ports throughout the world, and even in the Mediterranean campaign our vessels were able to serve, being defouled without having to dry-dock.

The second paper read on Thursday morning and the last of the series given during the conference was :

STRESSES IN PROPELLERS AND PROPELLER SHAFTING UNDER SERVICE CONDITIONS

By S. F. Dorey, C.B.E., D.Sc., F.R.S.

Synopsis

The object of this paper is to describe a number of problems, encountered by Lloyd's Register, which owe their solution largely to the application of electronic methods and to indicate further fields of uncertain knowledge to which such methods could be applied. Propeller blade defects are discussed and a method of measuring stresses in full-sized propeller blades is described, also the difficulties encountered. Service stresses in propeller shafting are reviewed, together with experiments with a tug and Great Lakes oil tanker.

Knowledge of torsional stresses in heavy weather needs extending, and shaft stresses in association with different forms of main propulsion units are reviewed. Bending stresses in propeller shafting are discussed under two headings, namely, those arising from changes in bearing alignment and those caused by hydrodynamic and inertia forces acting upon the propeller. To facilitate initial adjustment of bearings a simple strain gauge of high sensitivity has been developed, which gives a direct measure of cyclical bending strains. The low moment of inertia of the engine-propeller system with steam reciprocating engines is mentioned in association with that of the turbine vessel and the need for the fullest investigation into the problem.

Discussion

Mr. A. R. Gatewood (U.S.A.) : It was interesting to learn that the author feels that the use of strain gauges in association with a hollow-bored shaft would be the most satisfactory method for exploring the shaft strains between the stern tube and the propeller hub. We in the United States arrived at the same conclusion, and the Machinery Committee of the American Society of Naval Architects and Marine Engineers have only recently completed such tests at sea, utilising a hollow-bored shaft and strain gauges. The tests were carried out on one of the large single-screw 10,000 h.p., T2-SE-A2 type tankers. The object was to determine by direct measurement under service conditions the stresses occurring in propeller shafts in the critical region between the propeller and stern tube bearing. Preliminary results indicate that, when the ship is operating at normal service speed, reversed bending at propeller blade frequency considerably exceeds the static bending moment due to the cantilevered mass of the propeller, and is somewhat greater in the light ship condition than when fully loaded. This propeller blade frequency bending moment is believed to be due to eccentricity of thrust. In addition, bending moments were measured at various frequencies which were multiples of the propeller blade frequency.

These results are being studied in relation to the natural frequencies of the propeller shafting system in lateral vibration, which were determined, while the ship was in dry dock, by means of a vibration generator attached to the propeller hub. The natural frequency for motion in a horizontal plane was found to be substantially less than the natural frequency for motion in a vertical plane, both in the dry and in the immersed conditions.

A number of the fractures indicated that the principal stress could be in bending, which has been verified by the tests at sea. Tests by the American Bureau of Shipping on propeller shaft material have also proved that there has been no reduction in the quality of the material. Once accurate information is available regarding the actual service stresses, it would be much simpler, and certainly more economical, to carry out further research by using models. For example, as far as is known, no tests have been carried out to study the possible effect of the fretting action of a solid bronze propeller fitted on a steel shaft as compared with a cast iron hub fitted on a steel shaft. The entirely different characteristics of the two materials may prove to be of much more significance than has hitherto been supposed.

Dr. T. W. F. Brown (Great Britain) : I thank Dr. Dorey for having advocated so much the development of electronic instruments for measuring deflection, strain and similar factors. We still remain in the empirical stage of trying to decide the causes from first principles, and the paper has shown the complex nature of so many of the phenomena examined. I notice he has made several remarks about the use of the M.I.T. oscillograph, the bell type multi-channel recorder using films. Why use films when there are so many direct recording electronic graphical methods with pen recorders available ? There you see your record just as quickly as you take the measurements, and you do not have to wait until the film is developed, followed by extensive projection work. I note the use of the recording tape, which represents a very great advance over film work. The experiments on the " Jason Two " are extremely valuable by showing that strain gauges can be attached to propeller blades, and give results over long periods and still remain watertight and fairly glued to the blades.

Dr. S. Livingston Smith (Great Britain) : In dealing with stresses in propeller blades, one notes that, for the cast iron propeller quoted, the calculated stresses at the blade root exceeded the recommended safe limit for the material. It will be realised that the stress values obtained by the calculation given in Appendix A.1 can only be considered as approximate ; various unknown factors render absolute accuracy improbable in this problem, but the case quoted demonstrates effectively that it can be used as a guide to the safety of any particular design.

The author states that the service speed of the coaster concerned coincided with a major one-node torsional critical speed, and gives a calculation to substantiate this, and I would like to know how this calculated value compared with the actual value, and also the allowance made in the calculation for entrained water effect.

The case of the Great Lakes oil tanker raises a number of points in regard to the relative immunity of the starboard shaft. It is suggested that the machining and fitting of the keys may have played a large part in preventing rapid failure by reducing the stress concentration factor, but it seems hardly likely that all the port replacement shafts had some machining defects.

It appears that the fatigue strength of the tailshaft at its weakest point, the forward end of the propeller boss, is influenced by the standard of workmanship and the care taken in assembly. It is very difficult to ensure the most favourable operating condition for the shaft, and it is hoped to obtain information on the relative importance of the different variables concerned, by the fatigue tests referred to in the paper.

It is surprising that the type of vessel having the worst record in regard to tailshaft failures is the geared turbine " Victory " ship. Torsional stress variations have been considered to be of greater importance in connection with reciprocating machinery, but Dr. Dorey gives an ingenious explanation for the high shaft torque variation of turbine machinery in a heavy seaway.

I agree with the remarks regarding the importance of shafting alignment on bearing performance, and it appears that insufficient attention has been given to the positioning of lineshaft bearings, particularly at the after end, where the loading of the bearings can be altered by wear down of the stem bush.

Professor E. V. Telfer (Great Britain) : I was very impressed by the remark that it is generally in ships with balanced rudders that we have tailshaft trouble, and from my own experience I think it is true that balanced rudders are much more frequently associated with tailshaft troubles than are the ordinary kind. It is interesting to see the method by which Dr. Dorey has analysed the particular propeller whose blades broke three times, and it is a criticism of the practice of engineers that the propeller blade had to break three times before it was finally made satisfactory. Can he say what was done on the last occasion which enabled the propeller blade to remain on the shaft ?

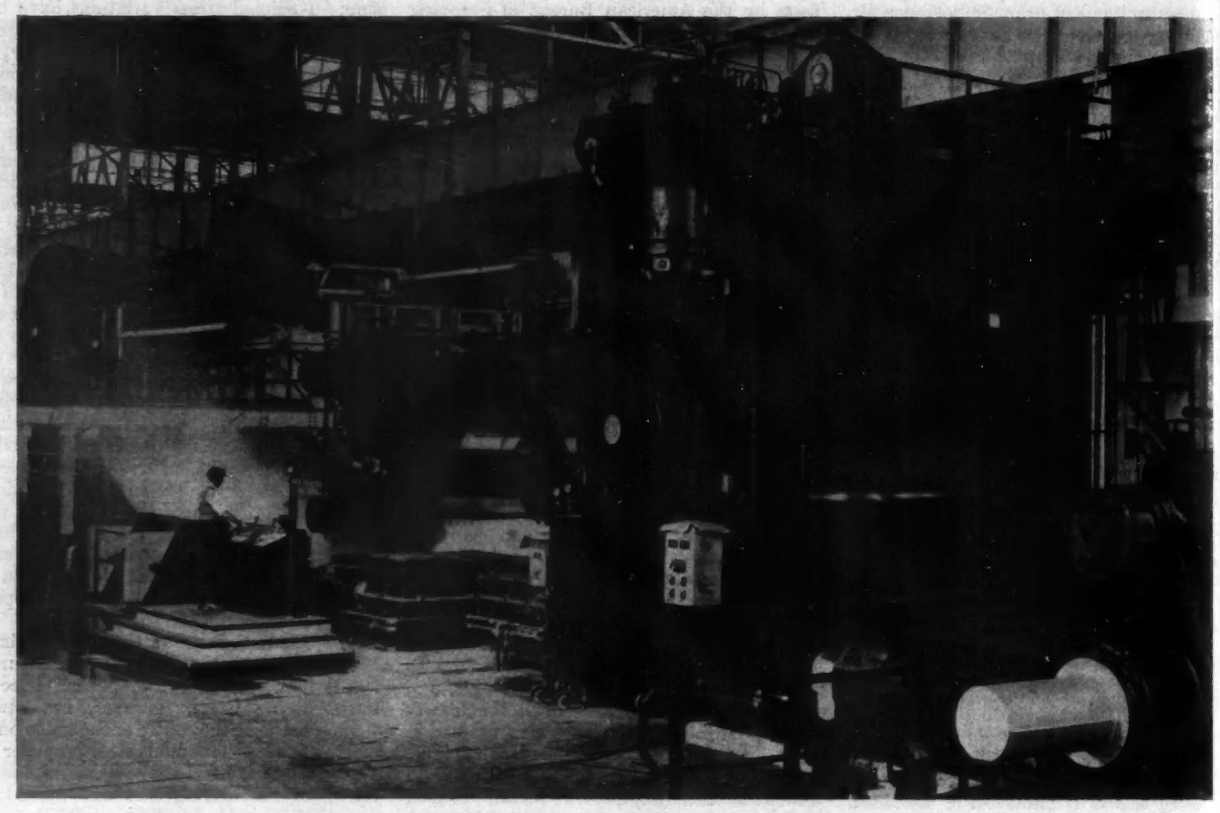
The calculation shows that the maximum tensile stress on the blade always occurs at the trailing edge of the propeller. Fracture never occurs there, however, but always somewhere near the centre of the blade on the driving face. The famous steel propeller was a case in which I feel the crack started at the centre of the driving face and spread out gradually over the whole propeller before it snapped. In that case there is no possible doubt that the cause of the fracture was shear or torsional stress, and I think that explains most of the propeller fractures we see to-day. I think Dr. Dorey is a little ambitious in trying to measure stresses at sea on propeller blades, for I am sure more can be learned in the laboratory as to whether a force applied to a model propeller will produce a certain kind of stress character in a certain place with a certain degree of accuracy.

Mr. H. G. Yates (Great Britain) : The shaft alignment indicator referred to in the paper is of great interest to me for the reason that an instrument using exactly the same principle was brought out at the Pametrada research station for aligning two shafts coupled by flexible couplings without making it necessary to break the coupling and rotate the shaft independently.

Dr. Dorey : Comments have been made with regard to the materials and the engineer. It has generally been the practice in the past for engineers quickly to condemn a material, but in my experience it is the engineer who is to blame, because he does not know sufficient about the stresses in the part concerned. We have much to learn, and I think it is by means of the apparatus now at our disposal that we shall be able to learn more of what goes on in the parts under actual service conditions.

I would emphasise that these tests cost a lot of money and time, and it is not simple to plan an arrangement and to get a ship when you want it. We want information with regard to behaviour in heavy weather, but we cannot always have people going around the world seeking it, and I hope the time will come when there will be apparatus on the ships and on each ship a competent person on the engineering staff who is able to take records when opportunity arises.

ROLLING MILL PLANT AT ABBEY WORKS, SOUTH WALES.



SLAB REHEATING FURNACES, SCALEBREAKER AND BROADSIDE MILL

80IN CONTINUOUS STRIP MILL IN OPERATION

The Margam and Abbey Steel Works

WHEN the British Iron and Steel Federation placed its plans for the development of this country's steel industry before the Ministry of Supply at the end of the war it recommended that sixty of the proposed £240 million to be spent should be allocated to a major reconstruction project in the South Wales sheet steel and tinplate industry. This project for South Wales was approved and after four years' work the Margam and Abbey plant was officially opened on Tuesday, July 17th last.

When the scheme was first proposed it was considered that so large a task of reconstruction was beyond the resources of any existing individual group of companies so that four of the largest companies in the industry formed the Steel Company of Wales. These four founder companies—the Guest Keen Baldwins Iron and Steel Company, Ltd., Richard Thomas and Baldwins, Ltd., John Lysaght, Ltd., and the Llanelly Associated Tinplate Companies, Ltd.—under the chairmanship of Mr. E. H. Lever, pooled certain of their resources. These resources, valued at more than £10 million, included a steel works at Port Talbot and Margam, eighteen tinplate works in West Wales and a sheet works at Newport.

The plans laid down involved the reconstruction and extension of the blast furnaces, coke ovens and coal and ore-handling plant at the Margam steel works in order to increase the production of pig iron to the required amount. The new Abbey works, to be built adjacent to the Margam works, comprised a new 80in continuous strip mill, together with a melting shop and ancillary plant. These two plants were to form one integrated works, which would, when completed, extend for 4½ miles and have an estimated annual steel production of 1½ million tons. An integral part of the scheme was the laying down of a cold reduction mill alongside the continuous mill at Margam, and a second cold mill with a new tinplate plant at Trostre, near Llanelly. The project has now been almost completed and, given suitable raw materials, will be capable of producing each week 15,000 tons of coke, 19,000 tons of pig iron and 30,000 tons of steel ingots. From the steel ingots will be rolled about 3500 tons of rails and railway material and 22,800 tons of steel strip and plate a week. Of this steel strip 7000 tons will be sent each week to Trostre to be manufactured into tinplate, whilst the remainder will be in the form of hot and cold rolled sheet and plates.

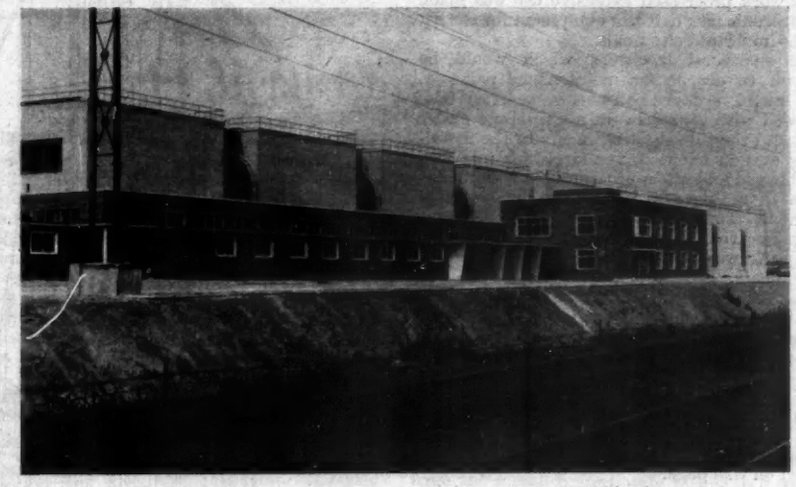
Reconstruction of Margam Works

Many problems were involved in enlarging the existing Margam works without interfering with production, and the effectiveness of the planning and the degree of co-operation between departments is shown by the fact that during this period a steady increase in production was noted in all sections. Following an investigation of the site conditions, the foundations of the blast furnaces were taken down to ballast strata at a depth of about 20ft and spread to give a maximum loading of 2½ tons per square foot. To provide for the penetration of heat these foundations were constructed with a centre core of heat-resisting concrete.

The No. 1 furnace of the works, which has a hearth diameter of 21ft 6in and was "blown in" in 1946, has a capacity of 700 tons a day. The original 16ft diameter No. 2 furnace was completely dismantled and a new 25ft 9in furnace, which was erected in its place, was "blown in" in November, 1950. The day after this furnace began operating, dismantling of the No. 3 furnace began, and the foundations have been completed for a new 25ft 9in furnace in its place. Using foreign ore, the No. 2 furnace has a capacity of 1000 tons per day and the No. 3 unit now under construction will have a similar capacity. A new Lodge-Cotterell gas-cleaning plant and an additional pig casting plant have also been installed.

In order to provide sufficient coke for the blast furnace installation, ninety new coke ovens have been built to supplement the output of the fifty-four ovens, which were already in operation. Sixty of the ninety new ovens have been in operation since March last and a new by-product plant has also been placed in service. To feed the ovens some 22,000 tons of coal is required weekly and it is brought to the site by rail wagons. These coal wagons are handled on gravity operated sidings, leading to wagon tipplers, which deposit the coal on to a belt conveyor feeding a new coal washing plant. From the ovens the coke is transported by means of conveyors to bunkers situated at each blast furnace.

Ore and limestone from home sources is also delivered by rail and the wagons are unloaded by tipplers on to a conveyor belt system, which carries the materials to storage hoppers. Ore from abroad for the blast furnaces is to be removed from the ships by three new transporter unloaders, which are being installed to replace two unloaders at present in operation. The new unloaders will be capable of handling 500 tons of ore per hour and are fitted with grabs of up to 12½ tons capacity. The wharf has been extended and a new concrete structure has been erected along the 1350ft long ore stockyard. On this structure 100-ton transfer cars have been installed for the unloading of material.



Cold Reduction Mill

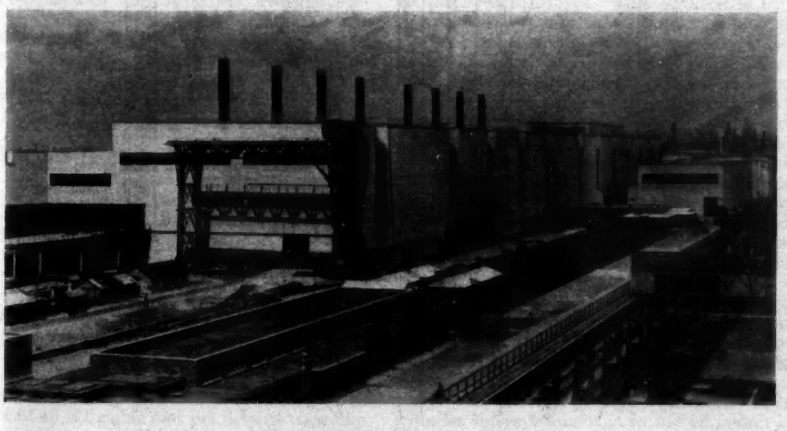
The six original open-hearth furnaces at Margam and six similar furnaces in the melting shops at Port Talbot are being reconstructed one at a time to 80-ton fixed furnaces. Up to date four of the furnaces at Port Talbot and five at Margam have been rebuilt. Hot metal from these shops is delivered by rail to the Abbey works melting shop, which we deal with below.

The Abbey Works

For the construction of the Abbey works which is built on a narrow, marshy coastal plain, the whole 550 acre site was raised about 10–12ft and the work involved the placing of about 4½ million cubic yards of filling. For filling purposes the readily available materials were sand from the dunes and slag from old tips in the vicinity and from the current production. In areas where early construction was not required sand was deposited by pumping from a dredger craft floating in a lagoon dug in the dunes. The lake formed by the operation of the dredger is now being used as a works reservoir.

Some 344,000 cubic yards of concrete were placed in the construction of the works and it was generally to a minimum specified strength of 2250 lb per square inch.

In order to prevent inroads by the sea and to stop sand from blowing in over the works a sand stabilisation project was carried out over about 83 acres. This work consisted of planting marram grass, which when established encourages other vegetation by fixing the sand and preventing drifts. This was later followed by the planting of Corsican and Maritime pine-trees. Low-lying areas of the foreshore were brought to a high level by fixing brushwood hedges against which the sand was blown by the wind until the hedge was buried. Increased height was obtained by fixing further brushwood on top of the buried portion. When



Abbey Works Melting Shop

up to the height required the dune so formed was planted with marram grass.

Fabrication has been used extensively in the structural steelwork and this form of construction is stated to have saved some 15 per cent over the equivalent weight of a riveted structure. Rigid frames have been used for nearly all the main buildings, some of which, including the main mill and melting shop buildings, are of open lattice construction. The bases of all these buildings are fully restrained.

An interesting feature of the main buildings is the fact that no base-plates have been used on the columns and in each case the column shaft is bonded to the actual pile cap and is, therefore, monolithic with the foundations. All gantry girders are continuous and were site welded at the joints over each column cap and the gantry rails were welded direct to their supporting girders.

As work progressed extensive use was made of ultrasonic flaw detector equipment for testing all the important site welds.

All structural steelwork which would be difficult to get at for maintenance painting, was metal sprayed and this practice was followed with all steelwork above crane girder level and the side sheeting rails. In the metallising system adopted, the steelwork was first grit blasted and afterwards sprayed with aluminium to a thickness of 0·004in by the wire method. The metal sprayed steelwork was given one coat of paint, whilst the remaining steelwork was power wire-brushed and given three coats.

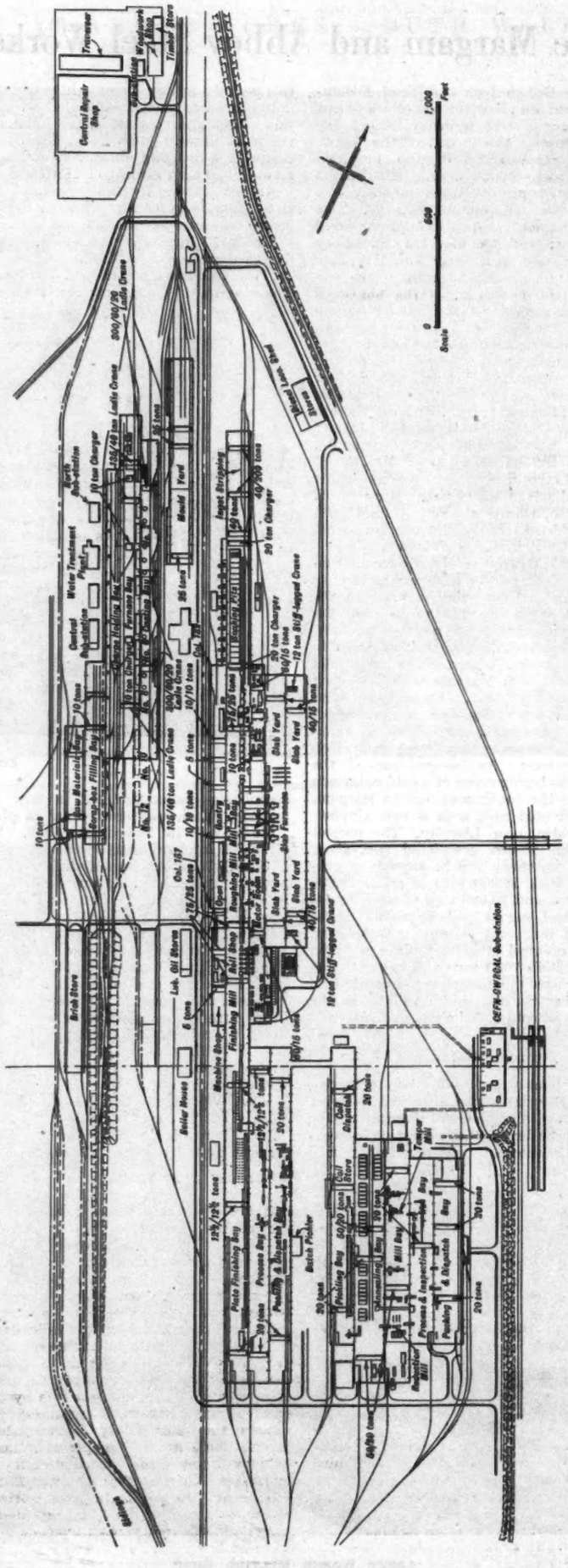
For the equipment laid down a large amount of interesting heavy foundation work was carried out and some of this work was described in the paper by Mr. W. S. A. Atkins, before the Institution of Civil Engineers, which was reprinted in abstract in our issue of April 7, 1950. In the following general description of the plant we refer to the plan of the works given with Mr. Atkins's paper and reproduced on this page.

Hot metal from the blast furnaces arriving by rail from the Margam furnaces is poured into one of two 800-ton elevated mixers arranged to pour directly into 75-ton ladles carried on transfer cars at stage level. As a ladle is filled it is hauled by an electric locomotive to the furnace, in which the iron is required. Of eight 200-ton fixed open hearth, oil-fired furnaces, which are to be laid down, four are already in operation. Each furnace has a 770 square foot bath with a depth of 31in, and scrap for them is supplied from the scrap marshalling yard in boxes on carriages running on a system of rails laid down on the loading platform.

The furnaces are tapped into 200-ton ladles handled by 300-ton transporter cranes serving the full length of the casting bay. A point of interest here is that each of the cranes, when carrying a full ladle, imparts a load of over 700 tons on the crane girders. To support the cranes twenty-two of what are claimed to be the largest welded girders yet made have been installed. The largest of these girders are 110ft long by 12ft 5in by 3ft and weigh over 90 tons.

The hot metal in the 200-ton ladles is teemed into ingot moulds standing on bogies on the opposite side of the casting bay. From this bay the moulds are hauled into a stripper bay, where the moulds are removed from the ingots by two 200/40-ton cranes. The moulds are returned to a cleaning and preparation shop and the ingots pass through the stockyard and on into soaking pits for heating prior to rolling. Of the twenty soaking pits to be installed, twelve are now in operation. These pits, which are 15ft 3in by 14ft 3in by 11ft deep, are fired by coke oven and blast furnace gas. When an ingot has been heated to the required uniform temperature it is removed from the pit by a 100-ton ingot bogie and deposited on a steel roller run-in table leading to the slabbing mill rolls.

Before it enters the slabbing mill stand each ingot is weighed and turned to ensure that its widest end enters the mill first. The 45in slabbing mill has 115in diameter rolls driven by two 4600 h.p. motors, and it rolls slabs up to 60in wide and 8½in thick. Leaving this mill, the slabs are conveyed along the roller table


Traverser
Central Repair Shop
Fabricating Workshops & Offices
Timber Store
Water Treatment Plant
Control Sub-station
Mould Yard
Ingot Stripping
Slab Yard
Brick Store
Lab. Oil Store
Boiler House
Roughing Mill
Finishing Mill
Mill Shop
Machine Shop
Gantry
Open Hearth Furnaces
Oil Dispatch
Oil Store
Motor Repair Bay
Plate Finishing Bay
Process Bay
Dispatch Bay
Bottom Pickler
Mill Bay
Inspection Bay
Temper Mill
Process & Inspection
Pickling
Dispatch
Stripper Mill
Slabbing Mill
Soaking Pits
Gantry
Ore Store
Ore Bridge
Ore Tipping Bay
Ore Bunkers
Coke Ovens
Coke Screening Plant
Coke Bunkers
Coke Wharf
Coke Loading Bay
Coke Tipping Bay
Coke Bridge
Coke Store
Coke Dispatch

to a vertical edger and slab shears where they are first trimmed to the required width and then cut into lengths. The trimmings are returned to the scrap stockyard and the slabs, after being weighed, are pushed on to a conveyor leading to a high-level table. The table carries the slabs to one of two pilers, which pass them on to transfer cars for removal to the slab yards for dressing and stacking.

Slabs which are to be used for rolling down to sheets are returned to the continuous mill, where they pass through one of a group of four reheating furnaces. Three of these furnaces are now in service and the fourth is under construction. They are triple-fired zone units, each 93ft 9in long and 20ft wide, and having a capacity of 105 tons per hour. From the reheating furnaces the slabs are carried on roller conveyors to the hot strip mill.

The Continuous Hot Strip Mill

The continuous hot strip mill comprises five roughing and six finishing stands, arranged in tandem, and it has a throughput of some 300 tons per hour. In it plates 72in wide and up to ½in thick can be rolled, as well as strip of the same width and down to 0·048in thick, at speeds varying from 900ft to 2100ft per minute, according to thickness. Slabs on entering the mill, first pass through a breaker stand, in which any scale formed during the reheating is removed. In the first roughing stand the slabs can be passed through sideways if it is required to increase their width up to 72in. They then travel through an edge squeezer and then on through three more roughing stands, each of which has a built-in edging mill. In one of the photographs we reproduce on page 112 the reheating furnace, primary scale breaker and the broadside mill can be seen.

As the plates leave the roughing mills they pass out on to a 186ft long run-out table, leading to the finishing mill stands shown in another of our illustrations. This long run-out table is in two sections and on it the progress of the plates can be delayed as required to permit a reduction in temperature before the finishing operation. From the last of the six finishing stands the plate passes out through a set of flying shears and on to a long run of roller conveyors leading to the coilers. These conveyors carry the strip at a speed of 2000ft per minute to one of two collapsing mandrel down coilers.

The coils are pushed off the coiling machines on to a conveyor, which carries them to an adjoining stocking area, from which at present they are despatched to other works for cold reduction and further processing until the cold reduction mills at Margam and Trostre come into operation later in the year. At Margam the strip will be cold rolled on a three-stand mill into wide sheets suitable for motor-car bodies, metal furniture, refrigerators, &c. At Trostre it will pass through a five-stand mill before being manufactured into tinplate.

Power Supplies

Three-quarters of the power requirements for the works will be supplied from the grid and the remainder from the company's power station at Margam. For this reason the existing power house has been extended to include a new boiler-house and pump house and most of the existing machinery is being replaced by new plant. Four new boilers have been installed and provision is made for a fifth at some future date. These boilers are designed to burn blast furnace gas as the main fuel and coke oven gas and oil fuel when blast furnace gas is not available. They each generate 87,500 lb of steam per hour at 625 lb per square inch and 820 deg. Fah. The new plant of the power station will consist of two 8000kW turbo-alternators, with provision for a future third set; two auxiliary 1800kW turbo-alternators; one turbo blower of 60,000 cubic feet per minute capacity; two turbo blowers of 80,000 cubic feet per minute capacity and one existing turbo blower of 46,000 cubic feet per minute capacity.

Power is transmitted to the works by four 66kV overhead lines and is transformed at works substations to 11kV for primary distribution within the works.

The principal distribution centres for Abbey works are at the strip mill and cold mill substations, where 11kV switchboards are arranged in five sections, which may be connected together by means of two bus reactor switchboards. Three sections supply the works base loads and are interconnected with Margam power station. The other two sections supply the peak rolling loads either direct to the roughing mill, through mercury arc rectifiers, to the finishing mill, or through synchronous motor generators to the cold mill. The peak rolling loads will be about 100,000kW.

The main distribution centre for Margam and Port Talbot works is at the power station. Here 11kV switchboards are arranged in three sections, two being supplied direct from two 8000kW turbo-alternators. The whole system is interconnected to provide reliable supplies to important departments, such as blast furnaces, coke ovens, melting shops, &c.

A secondary 3·3kV distribution system is supplied from 3500kVA, 11/3·3kV transformers, and interconnected to give adequate standby supplies. Motors ranging from 100 h.p. to 2000 h.p. are supplied from this system.

Motors below 100 h.p. and the general works lighting receive their supplies from a 415V low tension a.c. system, which is completely interconnected. A 440V d.c. distribution system is supplied from pumpless, steel tank, mercury arc rectifiers arranged in 1600kW units about the works, which provides a power supply for the cranes and mill auxiliary motors.

Light Metal Chromed Cylinders

ALUMINIUM alloys as material for pistons of internal combustion engines made their first appearance more than thirty years ago, when the tendency of increasing the engine speed forced the designer to keep the weight of the reciprocating masses as light as possible. It was soon realised, however, that aluminium pistons offered an additional and probably even more important advantage, namely, that of their excellent thermal conductivity which promoted a very much improved heat flow from the piston crown to the piston skirt and thus to the cylinder walls. It has been frequently suggested that in order to utilise the high thermal conductivity of aluminium engines the cylinder itself should be made of light metal, especially in the case of air-cooled engines. This idea, however, was considered impracticable owing to the poor resistance of aluminium to the abrasive action of the cast iron piston rings.

Several attempts were made in Germany as early as 1923 to run a light-metal piston in a sand-cast aluminium cylinder. Road tests carried out with a 500 c.c. motor-cycle had to be given up after 600 miles; the cylinder wear after this mileage amounted to more than 0·040in, and the oil pump was completely choked up by metal particles chafed off the cylinder walls. Metal spraying of the cylinder walls also proved to be a failure as it was impossible to obtain a secure bond between the steel layer and the aluminium base metal.

The only way, practicable at that time, of combining the good heat-conducting property of aluminium with a wear-resistant surface was the fitting of a steel or cast iron liner into a light-metal sleeve. This method is still being widely used for air-cooled cylinders. In connection with a light-metal cylinder head it represents a very effective way of improving the cooling of thermally stressed engines, and, though more expensive, it is greatly superior to cast iron cylinders. This solution is by no means ideal. Quite apart from the fact that the thermal conductivity of cast iron or steel is only about one-third that of aluminium alloy, the heat flow from the liner to the outer aluminium casting is interrupted by the inevitable, though minute, gap between the contact surfaces. These adverse conditions are further aggravated by the difference in the coefficients of thermal expansion of aluminium (about 22×10^{-6} per deg. Centigrade) and the liner material (about 10×10^{-6} per deg. Centigrade). It is possible, of course, to arrive by trial and error at an optimum interference fit which secures the liner firmly in the aluminium casting, but, as the temperature inside the cylinder is not evenly distributed the thermal expansion of the cylinder and the liner varies considerably between top and bottom dead centre, and the heat transfer is affected accordingly. In thermally highly stressed engines cylinder liners frequently go out of round and separate from the aluminium castings, allowing an insulation of varnish to accumulate between. This applies in particular to two-stroke engines, where disturbances in the heat flow from the very hot zone round the exhaust ports can lead to considerable distortion of the cylinder barrels.

Better conditions than with pressed-in or shrunk-in liners can be obtained with cast-in liners. A new process, recently developed in the U.S.A., aims at achieving a firm molecular bond between the aluminium sleeve and the ferrous liner.* For this purpose the liner, suitably cleaned, is immersed in a bath of molten aluminium. When the ferrous liner has attained the heat of the bath, it is attacked by the molten aluminium, and an aluminium-rich alloy forms at the surface; this part is now "wet" or "tinned" with aluminium alloy. The liner is then removed from the metal, immediately placed in a metal mould, and the aluminium casting alloy is poured around it. This poured aluminium fuses with the still molten coating on the hot ferrous part, producing, upon cooling, an intermetallic compound of aluminium and iron at the contact surface, and on the outside the aluminium casting of the desired form and shape.

This system undoubtedly represents an improvement and machining costs are considerably cheaper. On the other hand, it is not an ideal solution as the ferrous liner still forms a sort of dam, restricting the heat flow to the outer sleeve. It is also quite possible that thermal stresses in the intermediate zone, caused by frequent contraction and re-expansion of the liner, will alter the heat transfer characteristics of this compound cylinder.

In 1935, the Mahle Komm. Ges. of Stuttgart, who some years previously had been experimenting with unlined aluminium cylinders, took up this work again.† In collaboration with a British engineer, R. C. Cross, then chief designer of N.S.U., a German firm of motor-cycle manufacturers, they fitted some racing engines with unlined aluminium cylinders. Cross tried to avoid direct contact between cylinder and piston. For this purpose the cylindrically ground piston was fitted in the aluminium cylinder with a clearance of 0·030in and was solely guided by the piston rings of martensitic cast iron, which were very accurately adjusted in their grooves with a side clearance of about 0·001in to 0·002in. Further tests were made, on the test bed as well as on the road, with motor-cycle engines and air-cooled car engines of different size and make. The tests were extended over several years, but, on the whole, they were disappointing. Though all the engines were thermally only lightly stressed, they used to break down after 2000 or 3000 miles, and in one instance only could the distance covered be extended to 6000 miles. In all cases, the engine noise was considerable, the oil consumption high, the piston rings tended to stick, and there was an excessive amount of blow-by. The experiments were

* C. E. Stevens, *S.A.E. Journal*, January, 1950.
† E. Mahle, *Motortechnische Zeitschrift*, No. 4, 1950.

discontinued in 1938, at which time chromium-plating of iron cylinder liners was beginning to become a practical proposition and plating of aluminium was already in its first experimental stage.

The H. van der Horst Corporation in Holland and in U.S.A., started in 1932 with the chromium-plating of cast iron cylinder liners, and it is estimated that up to now more than 700,000 cylinder bores have been treated by

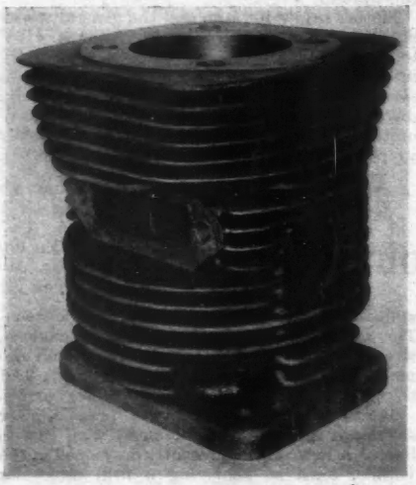


FIG. 1—70MM BORE ALUMINIUM CYLINDER—SAND CAST

this process. The characteristic feature of the van der Horst process is the porosity of the chromium deposited on the cylinder wall; early experiments had conclusively shown that ordinary dense chromium does not wet with oil, and that cylinder bores plated with hard chromium scuffed easily because of lack of lubrication.‡

The best method of providing a porous chromium deposit was to plate on a smooth surface, to obtain a workable and machinable coating of chromium (about 0·002in to 0·003in) more than is necessary for the final bore size. The cylinder is then removed from the plating tank and put into another tank, containing

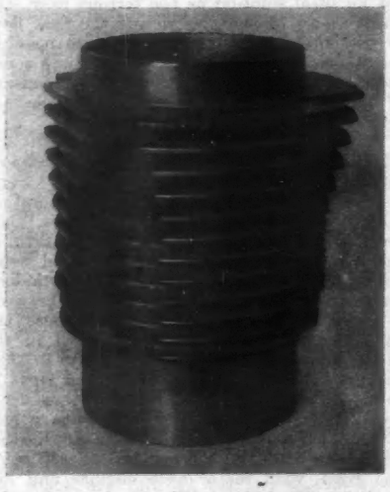


FIG. 2—ALUMINIUM CYLINDER—FORGED

another solution with the same anodes and the same set-up, but the current is reversed for a few minutes. The chromium is virtually stripped and results in a porous chromium surface, containing a multitude of pits and depressions, evenly dispersed over the whole cylinder wall, which serve as minute oil reservoirs.

Chromium-plating of aluminium cylinders, a process also developed by the van der Horst Corporation during the last war, is not basically different from that of steel or cast iron cylinder bores, as the ultimate aim is the production of a porous, oil-retaining chromium layer. Aluminium has the tendency to form an oxide layer on its surface which prevents its bonding with electrolytic deposits of other metals. A preliminary chemical treatment of the base metal is therefore required. The machined aluminium cylinder is placed in a bath, containing a strong caustic solution, which dissolves the oxide and any foreign matter, and exposes the grain structure of the metal, thus providing the necessary conditions for an atomic bond between aluminium and chromium. The pure metal surface has a minute irregularity which, by its mechanical effect, increases the security of the bond. The degree of irregularity is sufficient, when magnified by chromium during the electrolytic deposition of the latter, to provide the required porosity after the final honing operation. In order to prevent re-oxidisation of the pure aluminium surface during the transfer from the caustic bath to the plating tank, the solution contains enough sodium zincate to form a protective film, exceedingly thin and even, over the plating surface as the oxide is dissolved. In turn, this protective film is readily dissolved in the plating tank by the chromic acid, which serves as the electrolyte. After plating, the cylinder is honed to its accurate diameter. This final

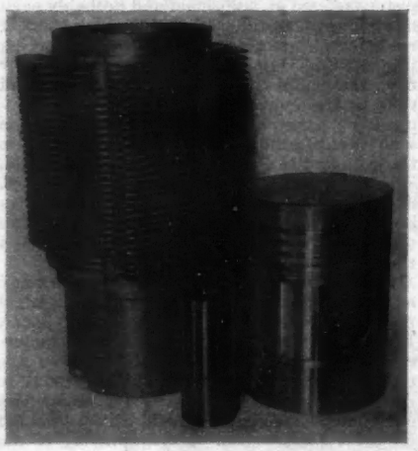


FIG. 3—110MM BORE ALUMINIUM CYLINDER

operation removes the surface irregularities down to about mid-depth leaving a heterogeneous, though evenly dispersed, pattern of oil pores.

Chromium-plating of cast iron cylinders has been, and is still, mainly confined to large cylinder bores of big diesel engines, especially marine and locomotive engines. It has proved extremely useful in increasing the life of cylinder liners between the reconditioning intervals, as the hard chromium surface is very resistant to abrasion and to corrosion by sulphuric acid. The same applies to plated steel cylinders of aero-engines, where the adoption of plating was found to almost double the life of cylinders. For the small bores of high-speed diesel and petrol engines plating is generally considered too expensive, and a compromise solution—the chromium-plating of the top piston rings—is frequently used in order to reduce cylinder wear.

The first firm known to have used chromium-plated aluminium cylinders in standard production engines was the Mall Tool Company, in Chicago. This company, making small portable air-cooled, two-stroke engines, started experimental work with plated cylinders in collaboration with the van der Horst Corporation in 1944. A report, published about a year ago§ deals with the outcome of this development work.

In preliminary experiments, the aluminium cylinder with pressed-in steel liner of an existing engine of 200 c.c. capacity was replaced by a chromium-plated aluminium cylinder. Without any alterations to bore and stroke it was found possible to increase the output of the engine from 4 h.p. to 7 h.p. simply by raising the compression ratio from 5 : 1 to 6 : 1 and by increasing the speed from 4000 to 4500 r.p.m. The pioneering experience gained in the first tests

FIG. 4—110MM BORE WET ALUMINIUM LINER

formed the criterion for a new design which utilises all the advantages associated with chromium-plating. The new engine, of only 130 c.c., has a compression ratio of 5 : 1 and develops 5 h.p. at 4500 r.p.m., which is 32 per cent more than the previous 200 c.c. model. The engine weighs 40 per cent less and is proportionately smaller. The significant increase in output is, of course, largely a direct result of the better cylinder cooling. The rapid diffusion rate, coupled with better finning,

FIG. 5—HARD CHROMIUM LAYER ON ALUMINIUM-SILICON ALLOY (×500)

reduced the parasitic drag of the cooling fan from 1 h.p. on the old engine to ½ h.p. on the new one. An undetermined amount of this cooling derives from the high reflectibility of the chrome, which reflects part of the combustion heat back to the gas so that it can be converted into mechanical energy. At the same time, the residual heat is dissipated more rapidly and with more even distribution throughout the whole length of the cylinder

‡ H. van der Horst, *The Iron Age*, July 8, 1943.

§ A. W. Mall, *The Iron Age*, December 1, 1949.

down to the flange. Further contributory factors are the improved frictional conditions, partly due to the low coefficient of friction between chrome and aluminium, and partly because the piston, which is fitted with a clearance of 0·002in only (against 0·007in of the previous model) requires only two piston rings instead of the three used in the 200 c.c. engine. Also, the use of chromium-plating instead of cylinder inserts allowed full advantage of the consistent accuracy of die casting to be taken. The metal cores used in die casting not only locate and form accurately, but produce a surface causing less frictional resistance to the gas flow. The shape and form of the transfer passages from the crankcase to the inlet ports and of the exhaust passages, was suitably

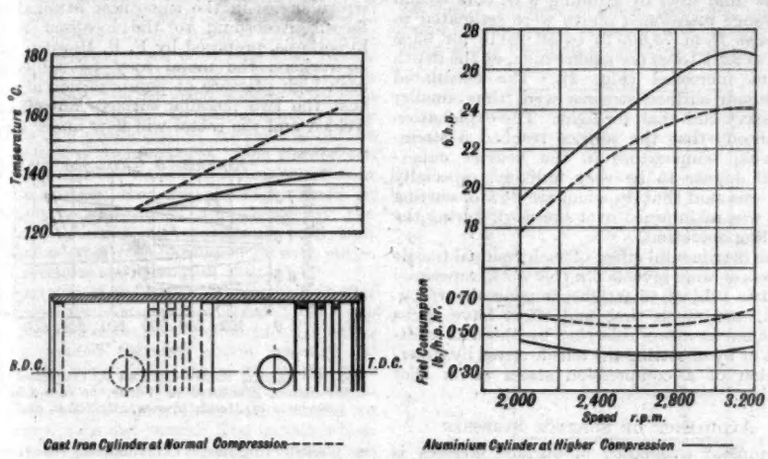


FIG. 6—CYLINDER TEMPERATURE, OUTPUT AND FUEL CONSUMPTION

altered, and the improved smoothness and contour also aided results. The blow-by was found to be quite negligible, and the cylinder wear, after 2000 hours, was 0·0006in on the diameter. These test results can be assumed as uniformly typical of the new production engines of which, by 1949, over 6000 had been manufactured.

On the Continent the encouraging results from U.S.A. caused the Mahle Komm. Ges. in Stuttgart to resume development work on aluminium cylinders which, during the war, was suspended. Based on its previous experiments with unlined aluminium cylinders and, further, on light-metal cylinders plated with hard chromium, the firm started new development work again in 1948, using a modified method of porous chrome-plating. Since then about thirty different types of air-cooled and water-cooled petrol and diesel engines have been fitted with chromium-plated aluminium cylinders or cylinder liners, ranging from 35mm to 120mm diameter and shown in four of our illustrations.

Some of the air-cooled test cylinders were cast in sand; others, for mechanically very highly stressed engines, were forged; but the majority were die cast. The cylinder liners for the water-cooled engines were made as centrifugal castings. A variety of aluminium alloys was tested, among them the usual aluminium-silicon piston alloys and the well-known alloys of the aluminium-copper group Y.R.R. 53, Hydronalium and Duralumin. Aluminium-copper alloys, however, have the advantage, if used in conjunction with an aluminium-silicon piston, that the higher operational temperature of the latter compared to the cylinder can be compensated by its lower thermal expansion. Cylinder and piston expansions can be balanced by selecting the piston and cylinder material according to their physical properties, so that they will expand and contract almost exactly together. The piston clearance, especially in the ring zone, can be kept down to a minimum, resulting in a very much improved heat-flow to the cylinder walls and reduced frictional losses. Cylinders of air-cooled engines, originally made of cast iron, should be redesigned for a greater fin pitch and larger fin cross section. The maximum cylinder temperature at top dead centre of such cylinders, suitably redesigned, is generally about 20 per cent lower than that of cast iron cylinders.

The cylinder wear after a distance of 40,000 miles was found to depend to a large extent on the process employed for the chromium-plating. Apart from the van der Horst process another process was used in which the surface roughness of the cylinder bore, as required for an atomic bond between chrome and aluminium, was not produced by chemical treatment, but by mechanical means. The cylinder, after the final fine-boring operation, is machined with a knurling tool which leaves a regular pattern of indentations on the surface. As the chrome deposit follows the contours of the base metal, the plated surface has all the characteristics of the latter, i.e., the evenly dispersed pits and recesses for the retention of the lubricant (Fig. 5). The finishing operation after plating, in either case, is done by honing. The experience so far gained in prolonged road tests seems to indicate that foreign matter and metal particles abrased from piston or cylinder are more readily taken up by the regular pattern of indentations of the mechanically roughened cylinder than by the irregularities of the chemically treated one. In view of the small piston clearance this must be considered a definite advantage as these particles, unless embedded in the cylinder wall, are liable to cause damage to the contacting surfaces, in particular to the softer piston material.

The number of ordinary production engines fitted with chromium-plated aluminium cylinders is still comparatively small, probably not more than 20,000, and the use of these cylinders, so far, has been mainly confined to small air-cooled, two-stroke engines. The greatest improvements in performance by the use of plated aluminium cylinders, of course, are to be expected in air-cooled engines, but water-cooled engines may also benefit by the use of aluminium liners, the outer side of which not being affected by rust. What can be achieved has been expressed by H. Mahle in his previously mentioned publication, which is based on experience gained in the last three years with thirty different makes of engines and in road tests extending over more than 1 million miles.

It includes curves of performance, fuel consumption and cylinder temperature of two identical air-cooled engines, one fitted with cast iron cylinders and the other with plated aluminium cylinders. The compression ratio in the latter engine has been raised to the limit set by the incidence of detonation (Fig. 6).

The publication states also that the life of plated aluminium cylinders between reconditioning intervals is at least double that of cast iron ones, a fact which to a large extent counterbalances their higher price, whilst the reduction of weight, offered by aluminium cylinders, is desirable in many cases. If used in conjunction with light-metal cylinder heads and crankcases, it is easier to arrive at suitable allowances for the accurate fit of these parts which all had practically the same coefficient of thermal expansion.

Chromium-plating is probably not the only way of utilising the advantages of light-metal cylinders. There is, for instance, the possibility of making aluminium cylinders with a number of cast-in laminæ of ferrous metal, arranged parallel to the cylinder axis and extending over the whole length of the piston stroke. These inserts, which have to take up the piston thrust and must be sufficiently hard to resist the abrasive action of the piston rings, might cover one-half or one-third of the total area of the cylinder walls.

Another promising design, at present being tested by the Mahle Komm. Ges., reverts to the old idea of applying a protective layer to the piston only. Considering the very successful results obtained by chromium-plating of the upper piston rings in cast iron cylinders, it is quite feasible that light-metal pistons, chromium-plated all over and fitted with plated piston rings, might yield equally good results, and road tests seem to support these assumptions. If fully successful, however, this new process would be considerably cheaper than the plating of cylinders, and might easily give a great impetus to a more general adoption of light metal cylinders, particularly in air-cooled engines for road vehicles.

Training of Locomotive Drivers as Motormen

PROGRESS on the Manchester-Sheffield-Wath electrification scheme has reached the stage when locomotive drivers normally engaged in steam traction are being trained to qualify as motormen in readiness for the opening of Stage I of the scheme from Wath marshalling yard, near Barnsley, to Dunford Bridge, at the eastern—or Yorkshire approach—to the Woodhead tunnel. Wath, where a new electric locomotive depot is nearing completion, has been selected as the training centre, and men are recruited from the staff of locomotive drivers employed at the Mexborough Motive Power Depot of the Eastern Region of British Railways.

The initial training consists of a fortnight's course for twelve men, one week being allocated to lectures with the aid of diagrams, and a second week to practical training, electric locomotives being used on a specially opened short section of electrified line. The lectures, which are given by a rolling stock inspector, deal with the mechanism of the electric locomotive. The locomotive drivers are also taught how to prepare and dispose of the locomotives at the start and completion of each turn of duty. During the second week of training the men are taken out on an electric locomotive in Wath exchange sidings under the control of leading motormen who qualified for these duties on the Liverpool Street-Shenfield electrification. Here, for the first time, the trainees handle a locomotive under electrified conditions and acquire practical knowledge of how to drive. Three electric locomotives are in use, each in charge of a leading motorman, who has two trainees in his care. After the fortnight's training the men undergo a short examination then return to steam working until the next phase of training.

Later this year, when the electrified line from Wath exchange sidings has been extended to Wombwell main exchange sidings, each group of men will resume training for a further week on electric locomotives, when they will acquire the necessary knowledge to drive freight trains.

The final period of training will take place in the latter part of 1951, when it is anticipated the line will be opened to a point near Barnsley Junction (Penistone). The men will improve their practical knowledge of how to drive freight trains by electric traction, including the experience of climbing the steep gradient of 1 in 40 up Wentworth Bank. This phase of training will be concentrated upon the practice of braking and regenerative braking.

Metallurgical Topics

Residual Stresses in Machined or Ground Surfaces

EXTREMELY high residual internal stress may be induced at the surface of a piece of metal under the action of a cutting tool or grinding wheel. Papers recently appearing in the "Transactions" of the American Society of Mechanical Engineers throw some light on this.

Dr. E. K. Henriksen[1] discusses residual stress in machined surfaces, showing that they are closely related to the work-hardening properties of the material. The stresses are concentrated near the surface and depend largely on the shape and angle of the tool. They are greatest in mild steel and may reach very high values in the vicinity of the tensile strength of the steel. They decrease with increasing carbon

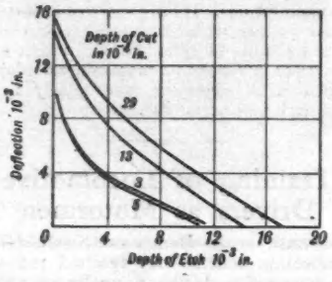


FIG. 1—*Deflection of Mild Steel Ground Bar as a Function of Depth of Etch (Frisch and Thomsen)*

content and with increased cutting speeds, but increase with feed and depth of cut. The stresses set up in the surface layers of ductile materials like carbon steels are usually tensile, but in cast iron the primary internal stress was found to be compression. The paper, while it contains no very novel information, constitutes an amplification and extension of that presented by Dr. Henriksen at the London meeting of the International Association for Testing Materials[2] in 1937.

Residual grinding stresses in mild steel were investigated by J. Frisch and E. G. Thomsen.[3] Mild steel bars were ground with a medium-soft grinding wheel in a surface grinder. The material employed was a ¾in by 1in bar of mild steel (carbon about 0·2 per cent) having a tensile strength of 26·3 tons per square inch and a yield of 17 tons per square inch. This was fully annealed at 870 deg. Cent. and was

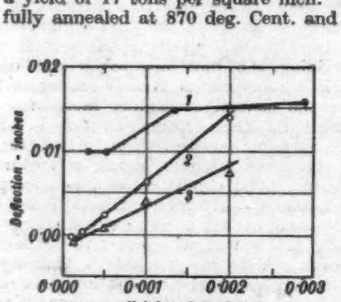


FIG. 2—*Deflection of Mild Steel Ground Bars in Relation to Downfeed with Grinding Wheel 38A46–J8VBE: (1) Frisch and Thomsen, (2) Tarasov; or Grinding Wheel 57A46–J12VBEP (3) Targeov*

then surface ground on both sides and again annealed at 870 deg. Cent. in hydrogen and slowly cooled. At this stage the specimens were free from stress. One surface was then ground. The conditions of grinding are described in detail. The curvature of the surface was measured, and the changes in deflection observed as successive layers of the surface were removed, not by further grinding, which might have introduced new stresses and so led to erroneous results, but by etching away successive 0·0001in layers with dilute nitric acid until the bar returned to its original shape. Some results are shown in Fig. 1. The thickness of the deformed layer was greater than that of the metal removed by the grinding process: for grinding cuts ranging in depth from 0·0003in to 0·003in the depth of the surface layer containing residual stress extended to approximately 0·012in to 0·018in below the surface. The thickness of the deformed layer increased with increasing depth of grind, but the maximum stresses induced at the surface of the mild steel by grinding with cuts within the range mentioned above were estimated to decrease from 75,000 lb to 50,000 lb (or 33·5 tons to 22·3 tons) per square inch, as the depth of cut increased (Fig. 2). The calculated maximum surface stresses were thus smaller for heavy cuts than for light. The explanation advanced—that the surface reached a stress-relieving temperature in the heavier cuts—would appear to be very unlikely, especially as it was said that an adequate flow of cutting fluid was maintained over the work during the grinding operation.

The detrimental effect of such residual tensile stresses as were revealed in this work, especially in parts subject to fatigue, is generally recognised, and much time and effort have to be expended in stress relieving by thermal treatment or by offsetting the tensile stress by superposition of a compression stress as in shot peening.

AVOIDANCE OF SURFACE STRESSES

Complete avoidance of surface stresses is difficult, and perhaps impossible, to achieve, but it would be a serious matter if the stresses reported in this paper could be taken as representative of the results of the best practice. Fortunately, their representative character was questioned by Dr. L. P. Tarasov, of the Norton Company's research department. He produced evidence from a parallel series of tests with the same grade of wheel. The main differences in conditions of test were that a certain amount of preliminary grinding was done with the dressed wheel before the test run was started, whereas a newly dressed wheel was used for every test by Frisch and Thomsen, and that a cross feed of 0·05in was employed at the end of each stroke instead of 0·375in at the end of the forward stroke. In these circumstances Dr. Tarasov obtained deflections increasing from zero with unit downfeed of 0·0001in to 0·015in (agreeing with Frisch and Thomsen) with a downfeed of 0·002in (Fig. 2). He pointed out that the deflections normally approached zero as the grinding conditions were made more gentle, and expressed the opinion that Frisch and Thomsen's results, wherein the deflections still remained high when the unit downfeed was very low were due mainly to the use of a wheel that had just been dressed, and to a very large crossfeed. Grinding data obtained with a freshly dressed wheel were, in his experience, unreliable; and deflections became constant only after several consecutive downfeeds following dressing. Lower deflections were obtained with a slightly softer wheel (Fig. 2) and other data showed that when unit downfeed was kept the same the deflection decreased towards zero as progressively softer wheels were used. All this was in accord with well-established practical experience that to grind a thin strip flat it was necessary to use gentle grinding conditions.

The results of Frisch and Thomsen's investigation may be taken as showing the importance of the correct selection and utilisation of grinding wheels, and the undesirable and even dangerous conditions (short of actual surface damage) which may be set up by departure from the best practice.

REFERENCES

[1] E. K. Henriksen: "Trans," A.S.M.E., January, 1951, Vol. 73, page 69.

[2] E. K. Henriksen: I.A.T.M. Report, 1937, page 173.

[3] J. Frisch and E. G. Thomsen: "Trans," A.S.M.E., April, 1951, Vol. 73, page 327.

Friction as a Function of Temperature

THE coefficient of friction measured in terms of the limiting angle of slip ($\mu = \tan\theta$) should be independent of temperature provided that the surfaces are clean and smooth and that there is no surface action dependent on temperature between the bodies in question. It is, however, well-known that surface effects play an important part in frictional behaviour. Extremely thin films of foreign matter may exert a profound influence. There are local irregularities in the smoothest attainable surfaces. According to the localised adhesion hypothesis, proposed by F. P. Bowden and his co-workers, the metal may be subjected to such high pressure at points of actual contact that the two metallic surfaces are effectively welded and the metal will flow under stress in

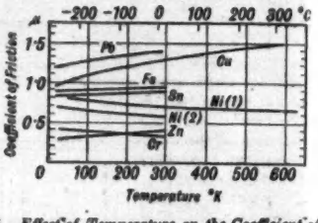
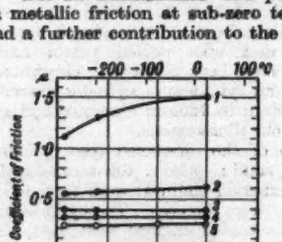


FIG. 1—*Effect of Temperature on the Coefficient of Static Friction, Measured in Vacuo, between Clean, Dry Surfaces of Metals (Simon, McMahon and Bowen).*

a plastic manner. The shear resistance of any individual adhesion spot to the applied tangential force is proportional to its cross-sectional area and to the shear strength of the welded metal. The area of actual contact varies directly with the force normal to the surface and is inversely proportional to the hardness of the metal. As pointed out by R. Holm[1] in 1938 and by M. E. Merchant[2] in 1940, the expression for coefficient of friction should include a term proportional to S/H, where S is the shear strength and H the hardness. Both S and H are dependent on temperature and a variation in the value of their ratio may cause a temperature variation in coefficient of friction.

Only a very limited amount of investigation has been devoted to the effect of temperature on coefficient of friction and still less to the effect of sub-zero temperatures on metallic friction. Dr. R. Schnurmann[3] has published data on metallic friction at sub-zero temperatures and a further contribution to the subject



(1) 0·16 per cent carbon steel; (2) Case hardened steel; (3) 18:8 Stainless steel; (4) 18:8 Stainless steel, nitrided; (5) Pyrex glass.

FIG. 2—*Effect of Temperature on the Coefficient of Static Friction of Steels and Glass (Simon, McMahon and Bowen).*

has now been made by I. Simon, H. O. McMahon and R. J. Bowen,[4] who have reported measurements of coefficient of friction between two unlubricated surfaces of the same metal in a paper entitled "Dry Metallic Friction as a Function of Temperature between 4·2 deg. K. and 600 deg. K." They determined limiting angles of slip on surfaces of the same metal at temperatures down to that of liquid helium and thus obtained values of μ for iron, nickel, copper, lead, tin and zinc. The values were not true static friction coefficients but rather

coefficients of kinetic friction corresponding to very small average velocities of the order of 1mm per second. These investigators also determined both hardness and shearing strength of the metals over the same range of temperature and, for comparison, drew curves expressing the relationship between temperature and (*a*) the observed values of μ, and (*b*) the observed values of S/H. The values of μ showed little change with rise in temperature. The temperature coefficients were rather small and usually positive. Only nickel and chromium showed a fall in the value of μ with rise in temperature (Fig. 1). The highest coefficients were those of lead and copper, both soft metals with a tendency to galling. Microscopical examination of the surfaces of copper in contact after fifty slides showed distinct evidence of a "ploughing" action, with transfer of material from one surface to the other. Lower coefficients of friction were observed with metals which have either a low shear strength or a high hardness. With hard metals the area of adhesion is small. In the absence of any adhesion the coefficient of friction would be independent of temperature. The harder the surface the smaller was the frictional coefficient and the smaller also was its dependence on temperature. Examples are shown by the behaviour of mild steel compared with that of a similar steel case-hardened, or with stainless or nitrided stainless steel (Fig. 2).

Comparison of the curves showing μ and S/H plotted against temperature showed that the curve for the measured coefficient of friction was, in general, approximately parallel to that of the ratio S/H. In spite of the considerable variation of shear strength and hardness with temperature, their ratio tended to maintain a constant value. The metals which showed the greatest discrepancy between the two curves also showed the greatest change in coefficient of friction with temperature, viz., lead and copper. It appeared that another temperature-dependent component of friction was also operating (the transfer or ploughing process) and the relative proportion of that component in the total observed friction could not be stated. All the observations were therefore found to be consistent with the localised adhesion theory of friction.

The actual values of the coefficients of friction were very much higher than those which would normally operate. Schnurmann's values for various metals ranged from 0·5 to 1·8, those of the later authors from 0·3 to 1·5. In both cases special precautions had been taken to secure degreased, degassed, clean and dry surfaces; and the measurements were made in evacuated vessels, in which the surface of the metal had been protected from all contamination. The formation even of a gas film on the surfaces of contact caused a rapid fall in the coefficient of static friction. A condensed layer of residual gas on one of the nickel specimens at low temperature led to a fall in its static friction coefficient to about one-sixth of its original value. The interest of the work lies mainly in the fact that it tends to substantiate the adhesion theory of friction proposed by F. P. Bowden.

REFERENCES

[1] R. Holm: *Wiss. Veröff. Siemens Werke*, 1938, vol. 17, pages 38 and 43.

[2] M. E. Merchant: *J. Appl. Physics*, 1940, vol. 11, page 230.

[3] R. Schnurmann, "Proc." *Phys. Soc. Lond.*, 1941, vol. 53, page 538.

[4] I. Simon, H. O. McMahon and R. J. Bowen: *J. Appl. Physics*, February, 1951, vol. 22, page 177.

High Temperature Properties of Graphite

In a recent paper[1] attention was called to the possibility of the use of graphite in parts of constructional assemblies which may be subjected to temperatures much higher than those which would be permissible with other refractory materials. The short-time tensile strength of five different grades of graphite (all products of the National Carbon Company, Inc., Cleveland, Ohio) was measured as a function of temperature. Details of the materials and of the results obtained are given in Table I and shown in Fig. 1.

TABLE I.—*Particulars of Graphite Examined (Malmstrom, Keen and Green)*

No.	Grade	Method of manufacture	Graphitising temperature	Approx. percentage of oriented grains	Density, g/cc
1	AGX	Extruded	2600 C	40	1·58
2	C-18	Moulded	2600	30	1·60
3	SA-25 ...	Moulded	3000	1	1·55
4	ECA	Extruded	3000	60	1·67
5	EBP	Moulded	3000	30	1·76

A characteristic common to all the strength/temperature curves is that strength approximately doubles on going from room temperature to 2500 deg. Cent. and then rapidly falls to zero as the sublimation point of graphite is reached. Young's modulus, measured on ECA graphite, increased steadily with temperature from about 1 million pounds per square inch at room temperature to about 1·4 million pounds per square inch at 2000 deg. Cent. The measurements of maximum load at high temperatures are profoundly affected by a very high creep rate.

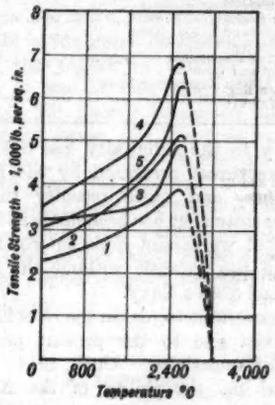


FIG. 1.—*Effect of Temperature on the Short-Time Tensile Strength of Graphites Referred to in Table I*

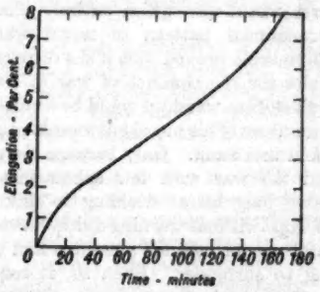


FIG. 2.—*Typical Creep Curve of ECA Graphite; Temperature 2500 Deg. Cent., Stress 4500 Lb Per Square Inch*

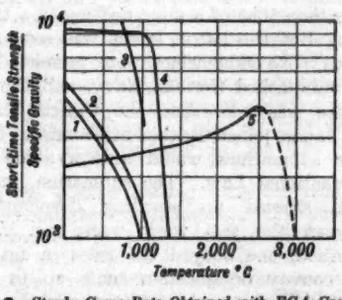


FIG. 3.—*Steady Creep Rate Obtained with ECA Graphite as a Function of Stress at Various Temperatures*

This characteristic was more fully investigated by further work on the ECA graphite. A typical creep curve for this material at a temperature of 2500 deg. Cent. and a stress of 4500 lb. per square inch is shown in Fig. 2. The steady rate of creep under these conditions was $6·2 \times 10^{-6}$in per inch per second, and the rate began to increase after two hours. Creep tests were made at stresses varying from 500 lb to 5000 lb per square inch and at temperatures from 2100 deg. to 2900 deg. Cent. with the results shown in Fig. 3. The fracture surfaces of graphite at all temperatures up to the sublimation point are typical of brittle material, even though a considerable amount of permanent elongation may precede fracture. Such deformation is due to the porous nature of the graphite mass and not to plastic deformation of individual elements of the structure.

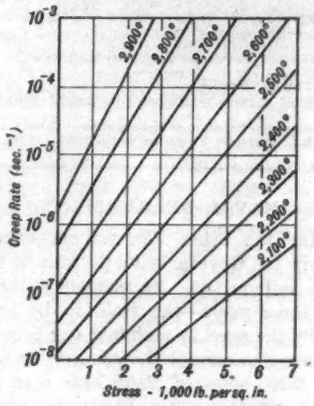


FIG. 4.—*Comparison of Graphite with Other Materials on the Basis of the Ratio of Tensile Strength (in Pounds Per Square Inch) to Specific Gravity: (1) Sintered BeO, (2) Sintered $MgAl_2O_4$, (3) Best High-Temperature Alloy, (4) Sintered Al_2O_3, (5) Graphite (ECA)*

In ratio of tensile strength to density graphite is inferior to other refractory materials below about 1200 deg. Cent., but is greatly superior to sintered alumina or beryllia at higher temperatures (Fig. 4). It is evident that crystal orientation in the graphite mass influences its mechanical properties, and the authors are stated to be making a further study of the subject in relation to orientation.

[1] C. Malmstrom, R. Keen and L. Green, jun.: "Some Mechanical Properties of Graphite at Elevated Temperatures," *J., Appl. Physics*, May, 1951, Vol. 22, page 593.

Glass-to-Metal Bonding

The General Electric Company, of Schenectady, New York, has developed a method of soldering glass to metal by a process which is said to make a bond stronger than the glass itself. This new method, which can also be used to solder metal to ceramics and carbon, is now being tested for industrial applications by the engineering laboratory of the company. The glass and metal areas to be soldered are painted with a thin layer of titanium hydride, and solder is placed on both painted areas. The parts are placed together and then heated under vacuum. When the temperature reaches about 900 deg. Fah. the titanium hydride decomposes. This causes the molten solder to adhere to the titanium-painted areas of both glass and metal, forming a strong bond upon cooling. By using soft metal solders, it is said to be possible to subject this glass-to-metal seal to rapid temperature changes without danger of cracking, despite the wide difference in temperature expansion of glass and metal. This property is possible because the differences in movement are absorbed by the solder. The new technique is now being used in the production of aircraft ignition systems, and laboratory investigations have suggested possible applications in the manufacture of transformers, capacitors and electric motors.

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NAVAL REARMAMENT

WHEN the Prime Minister announced in January the Government's decision to spend £4700 million on rearmament over the next three years—the scale to be limited only by the need to maintain our peacetime economy—he carried the country with him. Since then, however, there have been grave doubts whether our European commitments under the North Atlantic Treaty Organisation are not absorbing too large a proportion of our available resources in men and material at the expense of the Navy. The British Navy's officially declared dependence on the United States Navy for the protection of our imports of food and raw material, the suggestion of a Pacific Pact to be signed by the United States, Australia and New Zealand, the refusal of Argentina and Chile to abandon their claims to British territory in the Antarctic, and the general decline of our national independence and influence abroad, are all attributable, in the opinion of many thinking people, to the decline in the strength of the Royal Navy. Moreover, since the abortive conference of the Foreign Ministers in 1947, the British public has become increasingly aware of the possibility of war with Russia, and cannot understand why the Russian submarine menace seems to be more serious at the present day than it was a year or two ago. Now that the balance of sea power has been greatly affected by the submarine, the aeroplane and the atom bomb, the layman can no longer judge for himself the relative strengths of the navies of the world by counting the number of battleships each has built or building. He has to depend on the statements and explanations given by Government spokesmen both in and out of Parliament, and is bewildered by their change of tone. Two years ago the then First Lord expressed his confidence that we could deal with any threat from submarines which might develop at that time and said that the great majority of the 250 Russian submarines were of pre-war design. Viscount Alexander, a former First Lord, said practically the same thing. Since the Korean campaign, however, the Minister of Defence has spoken of Russia having "a very large number of submarines, many of which are of modern design"; the Parliamentary Secretary to the Admiralty has referred to the grave threat presented by the Russian submarines, and quite recently the very alarming statement has been made in a White Paper that we cannot hope to win another Battle of the Atlantic without the help of the United States Navy.

It is important to realise the reasons which have given rise to the present prevailing feeling of uneasiness. Until 1914, victory depended on the ability of the Navy to destroy or contain the strongest ships the enemy could build, whether galley, sailing ship or steel-built battleship. Then came the first world war which entirely changed the traditional pattern of naval warfare. The submarine proved that if she disregarded the rules for the conduct of war at sea, an enemy's surface warships could be evaded and large numbers of his merchant vessels could be attacked and sunk. Only because Germany started the war with few submarines and hesitated long before deciding to sink merchant ships without warning did we have time to build up our counter measures and avoid having to surrender. Even so, it required some 3000 anti-submarine vessels to deal with this revolutionary type of craft; in spite of her submerged speed being little more than that of a mine drifting in a tideway. But the lesson learnt was soon forgotten. No submarines were permitted to the vanquished German Navy, and though France was lukewarm, the United States and Japan joined Britain in promising that their submarines would always abide by International Law. The submarine, moreover, showed no startling development between the two world wars, and if, as promised, she obeyed the rules in future, the convoy organisation built up in the 1914–1918 war, could, it was thought, again be established to defeat her. Even the then Fleet Air Arm—which was to play a vital role in future naval operations—was trained and organised, not primarily for anti-submarine duties, but for Fleet action.

It was no wonder, then, that at sea the second world war was but a repetition on a larger scale of the first. Again, we were fortunate in that the Germans started late, for it was not until 1935 that they were permitted to build submarines. None the less, the thirty ocean-going submarines they had available in 1939 taxed our anti-submarine defences to the utmost, and it took us four years to check the submarine offensive, by which time our shipping losses had reached alarming proportions. In spite, therefore, of the technical nature of the question, the public have good reason to be alarmed in view of recent pronouncements by Government spokesmen. They know that we shall not again be given a breathing space, that the Russians will have very many more submarines than the thirty available to the Germans at the start of a war, that many of them are of modern design built under German supervision with submerged speeds of up to 19 knots or even more—a speed which makes all our remaining wartime frigates of little or no value. And they remember that to overcome the slower submarine in the last war the British Empire had to build 220 destroyers, 301 corvettes, 244 frigates and upwards of 1260 coastal craft of all kinds, besides a vast number of escort and patrol aircraft. On the credit side it is assumed that the efficiency of the Russian sailor is likely to be no higher in the future than in the past—though this assumption may be largely discounted if, as seems likely, their submarine crews are strengthened by ex-Nazi sailors from East Germany and the ex-German States. Russian submarines will also be at a disadvantage in having long distances to traverse from the Baltic and the Black Sea to the trade routes; but this again has been made much less difficult by the snort breathing tube which enables submarines to use their diesel engines submerged.

That the Government are now alive to the danger is indicated by their decision to build under the rearmament programme twenty-four fast anti-submarine frigates and to convert forty-five of our existing destroyers for anti-submarine escort duties. It is a good beginning, but in view of the five years' delay in starting, it is not enough. The Parliamentary Secretary has announced that by the end of 1952 the Navy's share of the labour force engaged in the shipbuilding and repairing industry will probably amount to about 30 per cent under the rearmament programme. It is not suggested that this proportion should be increased, for the Royal Navy and Merchant Navy are indivisible. But with our limited manpower and shortage of materials, it may well be that we are attempting too much in devoting so large a proportion of our resources to the Army, and that we should revert to our traditional policy of having a small, but highly efficient, contingent of troops for landing in Europe while maintaining a Navy strong enough to do its work without depending on a powerful ally. Ought not consideration, also, to be given to the possible advantages of constructing a new or converting an old shipyard for the rapid repetitive building of more or less standardised anti-submarine craft?

AERO-ENGINE RESEARCH

EARLIER in the year a meeting was held in London to celebrate the tenth anniversary of the first jet-powered flight in this country. At that reunion the place of honour was given to the now famous aircraft, the "E28/39," lent for the occasion by the Science Museum, and near it stood the "Whittle W.1" engine. During a speech made on that occasion the question was

raised by the Chief of the Air Staff, Sir John Slessor, whether the rate of development of that engine might not have been even faster. What might have been the effect on world events had "E 28/39" been able to make its first flight in 1938 instead of after hostilities had broken out in the second world war? This challenging and somewhat unexpected question was put to an audience which had heard much about a centenary of progress; and even was well aware of the vitally important and comparatively brief story of the part relating to turbine jet propulsion. So Sir John's hearers must have been intrigued by the suggestion that even this high level of speed might have been still faster!

The celebrations of the centenary of the Great Exhibition of 1851 have emphasised in the public mind the immensity of technical progress made in that hundred years of the world's history. We as engineers naturally look with pride on the share taken in those events by our grandfathers and our fathers, and are even bold to think that no small share of it derived from the work of the present generation. It is pleasant to realise that in the development of the turbine engine for aircraft this high standard of our own generation's energy was fully maintained. The Air Force must look with pride on the speed with which the promise shown by the young R.A.F. apprentice at Cranwell was recognised, and that once it was seen that Whittle's new invention must raise problems the solution of which required a considerable measure of aerodynamic knowledge, steps were taken to send the inventor for a spell of study in the University engineering school at Cambridge. Time cannot be said to have been lost by those in charge of the R.A.F. Training Directorate.

Those with the duty of assessing the value to the R.A.F. and to civil aviation of the new engine had a harder task, since, although any aerodynamic developments of a fundamental nature would naturally be taken under review by the official Aeronautical Research Committee, then under the vigorous chairmanship of Sir Henry Tizard, questions of comparable importance in the field of engine development would in the natural course of events be regarded as at least as much a matter for the industry as for any scientific committee. A similar division of tasks goes back to the earliest days of flying; the Wright Brothers had to design and build their first airframe themselves, but the type of prime mover they used was adapted from the then existing, if youthful, automobile industry. From that day forward new engine improvements came rather from industry than from any research establishment, even including the very well-run private laboratories, such as Ricardo's, which so ably carried out research investigations for the Government. It is true that the Aeronautical Research Committee, like its American fellow the National Advisory Committee for Aeronautics, had numerous engine questions pass through its hands, and was assisted by an engine sub-committee of its own, but the measure of responsibility it took for the progress of the art was naturally far less than that for which it was very ready, and for which it was splendidly qualified, on the purely aerodynamic side.

There were, nevertheless, certain fundamental questions that had to be settled—so far as they could—in respect of the design of Whittle's new turbine engine. What were the right shapes for the compressor and turbine blades? How far could one go in improving the mechanical efficiency of compression and expansion? Those questions could only be answered by those familiar with aerodynamic studies. At the exceedingly high velocities concerned, the shape of the air flow, and the forces concerned, alter markedly as sonic speeds are reached, and change yet again as those speeds are exceeded. The blade material involves novel metallurgical problems, and those of internal cooling as well. This makes it hard to be confident, even in the light of the fuller knowledge we have to-day, whether any steps could have caused the speed of development of the engine to surpass the high standard it was already setting for itself. So, though Sir John's intriguing question may, and no doubt will, give rise to many speculations, the record of the Air Force in this respect, and perhaps even of its Ministry, contains little of which it need feel ashamed. If the vital criterion to-day is the place attained in the world by the British jet propulsion engine there is indeed room for congratulation.

Literature

Chemical Analysis of Cast Iron and Foundry Materials. By W. WESTWOOD and A. MAYER. London: Allen and Unwin, Ruskin House, 40, Museum Street, W.C.1. Price 42s.

THE value of this publication is adequately described in a paragraph from the foreword by Dr. Gregory (Edgar Allen and Co., Ltd.), who says: "They have appreciated the need for fully detailed instructions in any analytical method and, in addition, have given full thought to the theoretical principles involved so that even a beginner should be able to obtain reasonably accurate results, always provided, of course, that he has previously received adequate training in the fundamental sciences of chemistry and physics."

Introductory comments on laboratory apparatus and techniques are a feature of most textbooks of this kind, but the authors appear to have given in their early pages a helpful selection from the items of information usually supplied, and one is only regretful that they have not expressed a rather more encouraging opinion of the application of analytical spectrography in the cast iron field.

In the section dealing with the analysis of cast iron, the determination of each element is introduced by a discussion of procedures already published, a brief statement of the principles involved in the recommended method(s) is given, the sequence of operations is detailed and a review of the theoretical basis of the reactions employed is presented. Practically every element which might be encountered is considered, and, while occasionally a particular operator may prefer a more familiar method, all the techniques proposed have evidently been carefully chosen for the purpose in view.

The comprehensive nature of the work is again evident in the section on the analysis of ferro-alloys and other iron-making additions, where, with a similar lay-out to the preceding matter, information on the usual composition of, and the determination of essential constituents in a wide range of commercial alloys, is also provided.

Iron ore, both as received and after various treatments, generally presents an analytical problem which increases in difficulty with the increasing impurity of the material. The authors have recommended a scheme of analysis applicable to a wide range of ores and, although they do not appear to have examined in sufficient detail the limitations of stannous chloride reduction in the determination of total iron and the advantages of hydrogen sulphide in certain instances, the more usual constituents are adequately dealt with.

Subsequent sections, devoted to the analysis of slags, siliceous and related products, coke and coal dust are evidently based, as in the earlier part of the work, on sound theoretical and practical knowledge, while the concluding section on the sampling and testing of linseed oil will be of value to all chemists associated with foundry control.

A commendable feature of each section is the description of a suitable technique for obtaining a representative sample of the material to be analysed, and not the least useful pages of this treatise are found in the appendices, where laboratory furnace construction, equipment, lists of compositions, conversion factors and an extensive bibliography may all be found. The illustrations are of a uniformly high standard and contribute in no small measure to the clarity of the text, the whole volume being well worth a place on the bookshelf of any metallurgical analyst.

SHORT NOTICES

Bearings and How to Fit Them. By Ian Bradley and Norman Hallows. London: Percival Marshall and Co., Ltd. Price 3s. 6d.—This is a typical Percival Marshall booklet, elementary, but sound, with excellent illustrations, by two authors who have done much for the home workshop and the engineer in a small way. It covers plain bearings, roller bearings, ball bearings and needle bearings, mentioning, very properly, with regard to the last-named, that they are better for reciprocating joints than for continuous-running bearings. The chapter on plain bearings covers only the familiar materials, white metal, bronze, cast iron, and so on, and has no more than a passing allusion to non-metallic bearings. The good red fibre that one used to be able to get readily is admirable for reasonable loads, journal and thrust, and worthy of mention, and even wood might have had a word. Discreetly used, it has its merits in the home workshop. In the matter of ball and roller bearings $\frac{1}{4}$in is given as the minimum size. The authors appear to have overlooked the miniature bearings, down to much smaller sizes, that are now available.

BOOKS RECEIVED

Basic Refractories, Their Chemistry and Their Performance. By J. R. Rait. London: Iliffe and Sons, Ltd., Dorset House, Stamford Street, S.E.1. Price 60s.

The Motor Vehicle. Fourth edition. By K. Newton and W. Steeds. London: Iliffe and Sons, Ltd., Dorset House, Stamford Street, S.E.1. Price 35s.

Electrical Engineers' Handbook. Fourth edition. Edited by Harold Pender and Knox McIlwain. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. 68s.

Diesel Fault Tracing Maintenance and Repair. By Staton Abbey. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, W.C.2. Price 15s.

Structural Theory and Design. Volume I. By J. McHardy Young. London: Crosby Lockwood and Son, Ltd., 39, Thurloe Street, South Kensington, S.W.7. Price 25s.

Shoreham Cement Works

A NEW cement works at Shoreham, in Sussex, has recently been brought into full production for the British Portland Cement Manufacturers, Ltd. The works has a capacity of some 350,000 tons of cement a year and replaces a small works which has been in operation for the past fifty years. The accompanying illustration gives a bird's eye view of the new works, which has been largely built on the floor of the existing quarry; the old works may be seen in the right foreground. Although following along the general lines which have become standard practice in the cement industry, the new works incorporates a number of interesting refinements, and may be said to be a good example of modern practice. A noteworthy point is the installation of electrostatic precipitators and dust removing plant, which make the works virtually dustless.

SHOREHAM CEMENT WORKS

The principal raw materials, chalk and clay, are obtained from nearby quarries. The clay is made into a slurry and pumped to the works into a storage tank, which may be seen to the left of the main building in the illustration referred to above. The chalk is crushed in a crusher house shown on the extreme left, and transferred on a belt conveyor to the primary washmills, where it is mixed with the clay slurry as they both enter the mills. The coarse slurry thus produced is broken down and mixed to the required limits in the washmills and is then pumped to mixing tanks, which allow an adjustment of its chemical composition before passing to storage tanks. Compressed air agitation is used throughout these tanks. The slurry is then fed to rotary kilns by three-throw plunger pumps, with variable-speed spoon-feeders to control the quantity delivered to each kiln. The two kilns are each 350ft long and 10ft in diameter at the barrel, with rotary clinker coolers 90ft in length. Pulverised coal is fed to the kilns from mills and storage bunkers. There are two electrostatic precipitators, one for each kiln, operating under suction from induced draught fans, both kilns then discharging into a reinforced concrete chimney 300ft high and lined with bricks throughout. After leaving the coolers the clinker is conveyed either to a store or to the grinding mill bunkers. The grinding mills are situated in the building in the background of the aerial view mentioned above, to the right of the main building, which contains the kilns and main stores. Gypsum is added to the clinker as it passes to the grinding mills, its function being to retard the setting time. Twelve cement storage silos with a total capacity of 15,000 tons have been built and may be seen in front of the grinding mill building in the illustration. There is space for four more. Cement in bulk may be taken directly from these silos, but there is also a bagging plant. The limitations of the site necessitated placing the bagging plant, together with the office and laboratory block, on the other side of the road adjacent to the old works. An overhead conveyor system is therefore provided to transport cement from the silos in one direction and coal and gypsum in the other.

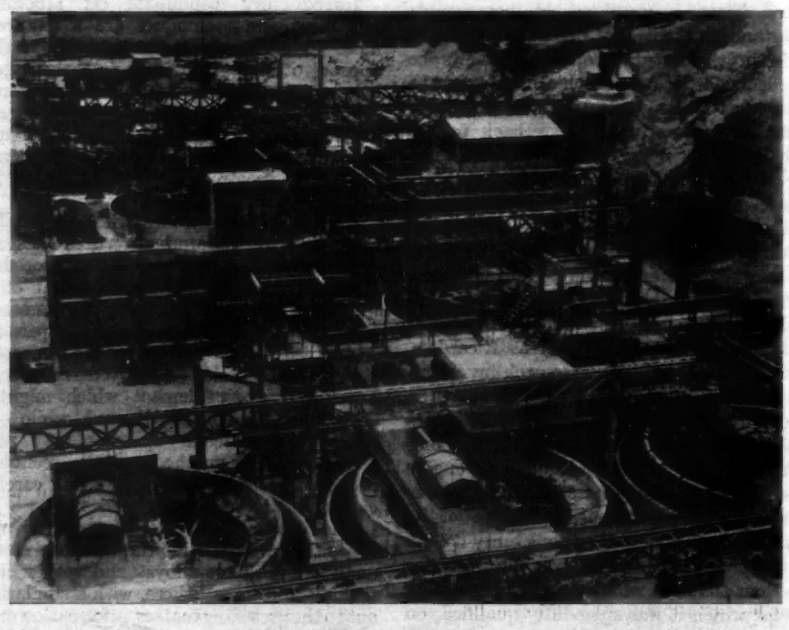
The chalk of the floor of the quarry has provided a good foundation for the structures of the main part of the works, but the office block, packing plant and packing plant silos are founded on reinforced concrete piles, since the chalk dips steeply towards the River Adur, where alluvial deposits are present. The kiln building is steel framed, but contains extensive reinforced concrete work. In fact, the structural design of the works was of considerable complexity, involving a wide variety of conditions of loading and of structural shapes, depending on the element under consideration. Each of the main units had its own structural problems—the washmills carry heavy live loads and the mixing tanks a considerable liquid head. Temperature variations are important in the case of the structure of the electrostatic precipitators. The kilns themselves are carried on substantial H-shaped piers of reinforced concrete, which are some 33ft in height at the higher end of the kiln, giving a pleasing and impressive appearance in the interior of the kiln house. The main stores and bunkers associated with the kiln house have necessitated substantial reinforced concrete work, including retaining walls up to some 30ft in height. The packing building and office block are both of reinforced concrete. Asbestos cement sheeting has been extensively employed as a cladding in the works, and various sorts of concrete blocks have also been employed; the laboratory and office building is faced with "tyrolean cullamix," a decorative finish applied with a cement gun.

The works has its own substation, where power from the grid is transformed from 33kV to 3kV. There is then an extensive distribution system leading to the various items of plant in different parts of the works.

Chalk and Clay Quarries

The clay plant at Horton comprises a self-contained unit for clay slurry preparation, with its own substation and messing accommodation for the workmen. Clay is dug by a multi-bucket excavator loading on to 24in sectionalised belt conveyors to a 25ft washmill, which discharges clay slurry containing about 70 per cent of water to a 52ft diameter storage tank equipped with rotating paddle mixers. Housed alongside this tank are three three-row reciprocating high-pressure slurry pumps which pump the slurry through 2½ miles of twin 8in mild steel pipe-lines to a storage tank at the main works. The pipe-line has welded joints and is heavily protected with bitumastic compound and is asbestos sheathed to withstand corrosion.

The clay slurry at the works is stored in a 66ft diameter concrete tank equipped with a rotating girder carrying pipes to the bottom of the tank for air agitation. From this tank the



WASHMILL INSTALLATION

slurry passes to a breakhead tank which maintains a constant head above two centrifugal sand pumps used to deliver to a spoon feeder metering clay slurry to the chalk washmills. The excess pumped to the spoon feeder returns by gravity to the storage tank.

The old chalk quarry was worked as a single face which had developed to a height of 180ft. The new quarry will be benched, the first bench being a cut along the top about 40ft high, some way back from the old face.

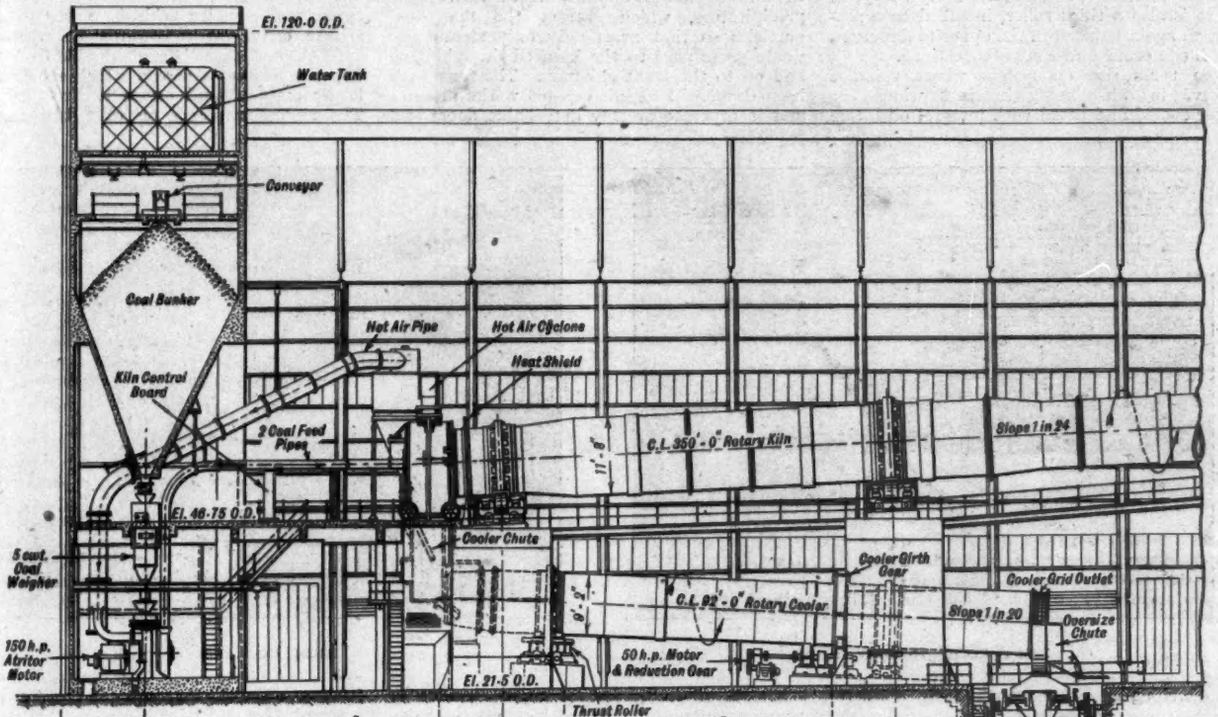
A 3½ cubic yard electric navvy collects the chalk and deposits it into 9 cubic yard dumpers holding 12–13 tons chalk, which transport it to a 7ft 6in by 4ft twin roll claw crusher. The crusher, with a capacity of 300 tons per hour, reduces the chalk to about minus 10in cube and discharges by gravity chute to a crushed chalk stockpile at works level holding sufficient material for a day's supply to the chalk-washing plant. Chalk is taken from the pile by an electric grab crane which discharges into a separate crossbridge, which also carries the top location for the king post of the wash mill. The final reduction gears are totally enclosed and lubricated by oil spray and the use of two bridges is designed to insulate the motor and gearbox from any vibration in the mill. The roughing and secondary mills are driven by 350 h.p. motors and the screening mills by 100 h.p. ones.

The mills are arranged on three levels so that the slurry gravitates through launders from the roughing mills to the secondary mills and again through launders to the screening mills, which discharge to a slurry trough. Above each level of washmills run hand-operated overhead travelling cranes for maintenance work.

From the slurry trough, 6in centrifugal pumps deliver the slurry to the preliminary mixing tanks. After sampling and preliminary blending by centrifugal pumps between the tanks, the slurry is pumped by similar 8in

under these hoppers empty the flints on to belt conveyors which rise and carry the material to a chute feeding the rotary flint washer, which is 24ft long by 4ft 6in diameter. It slopes upwards at 5 deg., and cascades the flints by spiral lifters through water introduced at the top of the washer, which effectively removes any chalk still adhering to them. At the end of the washer are screen plates which divide the flints into over and under 2in, each size discharging on to a separate belt conveyor. The oversize, or pottery flints, go direct to rail wagon or to a stockpile, and the undersize are taken to another storage area for rubble.

The secondary washmill has a washout duct from the floor of the mill, through which there is a continuous flow of the small flints, &c., which have passed the screens of the roughing mill. The duct leads to an elevator, which discharges into a rotary screen, the undersize flints (—¾in) passing to a washing screw serving the same purpose as the flint washer, and dis-



FIRING END OF KILN AND KILN COOLER

feeder for the 30in chalk conveyors supplying the roughing washmills.

On this belt conveyor is a weighing machine which records the feed rate of the conveyor and summates the total feed. As each 10 tons is summated, a contact is closed which starts the spoon feeder which delivers the clay slurry to the wash mill; a synchronous-motor-driven timer allows this feeder to run for a given time and then stops it until the next 10 tons restarts the cycle. In this way correct proportioning of chalk and clay (about 3·8 to 1) is obtained.

Slurry Preparation Plant

The chalk-washing plant consists of two roughing mills, one secondary washmill and three screening mills. All the mills are 35ft in diameter and their full circumferences are used for screening, except in the roughing mills, where 85 per cent is used. A departure has been made from the traditional drive depending on a machine-moulded bevel wheel and pinion. The drive motor is now mounted on the mill overbridge and directly coupled to a helical and bevel reduction gearbox, the output shaft of which is vertically downwards. Coupled to this shaft is the pinion shaft of the final reduction machine cut spur gears, the wheel of which is mounted on the rotating harrow frame. The pinion shaft runs in a housing mounted on a

pumps to the final mixing tanks. Here further sampling and correction is carried out until the desired chemical composition is obtained, when the slurry is discharged by gravity into 66ft diameter storage tanks. There are three of these tanks, each having the same stirring and air agitation equipment as the clay slurry tank. The mixing tanks are conical-bottomed silos which are air-agitated to obtain homogeneous mixing of the slurry. The rota of blowing air in the silos is controlled by electrically operated sequence valves. Air-operated depth gauges are used to determine the quantity of slurry in the tanks. Owing to the high head, a breakhead tank is used to control the inlet head on the centrifugal pumps under the preliminary mixing tanks.

From the storage tanks the slurry is pumped by three three-row reciprocating slurry pumps (situated under the final mixing tanks) to a distribution box which divides the feed to the two spoon feeders, each supplying one kiln, the excess from the feeders returning by gravity to a storage tank. This arrangement allows one pump for each kiln and one acting as a standby.

The roughing washmills have flint extraction doors in their floors through which the flints collected in the bottom of the mill are discharged into concrete hoppers. Jigger feeders

charging into a storage area. Sometimes the oversize material (+¾in) is returned to the secondary washmill to assist the washing process.

From the screening mills a continuous bleed of grit and slurry passes from a duct in the floor of the mill to a sump. It is pumped from there by a centrifugal pump to a bowl and rake classifier, in which the +100 mesh grit settles out and is discharged to a dump. The slurry is pumped from the classifier to a thickener. The wash water from the flint and beach washers is pumped to the same thickener, in which the solids settle to the bottom in a slurry and the clear water from the top is reused. The slurry from the bottom of the thickener is pumped back to the roughing washmills, being fed in with the chalk and the clay slurry. This washing plant enables 6 tons of slurry to be returned for use for every 100 tons of chalk passing through the washmills.

Power supply to the slurry preparation plant is controlled by switchgear grouped at one ten-panel board comprising two 0·3 square inch incoming feeders, four 350 h.p. slip-ring motors (one to be installed in the future), for driving the roughing and secondary washmills, two 600kVA step-down transformers for auxiliaries, and one 0·4 square inch outgoing feeder to the quarry substation, supplying

power to the 200 h.p. Ward-Leonard set of the excavator.

The Kilns

The two kilns are designed to produce not less than 23 tons of clinker per hour at a fuel consumption of not more than 23 per cent standard coal (12,600 B.Th.U. per pound) and to operate continuously for 95 to 96 per cent of the year. They are 350ft long by 10ft diameter with the burning zone enlarged to 11ft 6in diameter, made of 1in thick plates for the first 110ft and the remainder ⅞in thick; they are fired by pulverised fuel. Shops joints in the plates were made by the "Unionmelt" process and the site joints were riveted. The nose ring is of 1½in plate and is renewable. They each slope at 1 in 24 and are supported on six tyres, while the down thrust of each kiln is taken on one fixed thrust roller and a second roller equipped with deadweight balance through a pulley block system. This method eliminates any need to cut the kiln supporting rollers and so reduces their wear and that of the tyres. There is also a third roller, installed as a precaution against thrust in the opposite direction, which can occur under some conditions.

The tyres run on rollers whose spindles revolve in self-aligning bearings which are water cooled and fitted with integral oil lifters for distributing oil on the bearing surfaces. The bearings rest on cast iron bed-plates, the out thrust of the rollers being taken by independent steel castings held in by long tie bolts passing through the bed-plate.

Curtain and festoon chains are hung in the drying zones to form a heat exchanger and to minimise dust. Alumina bricks are used for the linings and the nose ring castings are of heat-resisting steel. The kiln temperature is about 2650 deg. Fah. and the slurry is calcined for about 3½ hours.

Under each coal hopper supplying the kilns is an atritor coal pulveriser, the pair of atritors firing No. 1 kiln being fed through 5-cwt batch weighers, which are introduced as a check on coal consumption. The atritors draw their hot air for drying the coal from the kiln hoods, as shown in the accompanying elevation of the firing end of the kiln, the air passing through cyclones to extract the clinker dust which is discharged into the clinker chute. Two atritors fire each kiln, although one is sufficient to operate a kiln at reduced output. Oversize rejects from the atritors pass to an underground screw conveyor and are taken to the store by an elevator.

Each kiln is driven by a 150 h.p. variable-speed motor through a vee rope drive to a reduction box. Further reduction gears are fitted on the drive bed before the girth gear which is attached to the kiln by tangent plates. The speed range of the kilns is from 0·67 to 1·33 r.p.m. and they rotate in an anti-clockwise direction viewed from the firing end.

Clinker is discharged from each kiln into a rotary cooler, 90ft long by 9ft diameter, which reduces its temperature to 230 deg. Fah. The coolers are each supported on two tyres and slope at 1 in 20, fixed thrust rollers being used for the down thrust. Special attention has been given to the design of the lifters in these coolers to achieve an evenly distributed curtain of falling clinker to ensure maximum cooling from the incoming air. Each cooler is driven by a 50 h.p. fixed speed motor, the drive arrangements being a smaller replica of those for the kilns. The cooler and the firing end of the kiln are shown in the illustration on page 123 which also shows the coal plant. The kiln drive is situated at the next point of support to the right, which is not shown in that illustration. The illustrations below, however, show the upper part of the kilns, including the girth gear, and also the kiln coolers.

The air passing up the coolers forms secondary air for the combustion of the pulverised coal. The combustion gases, together with the steam and CO_2 driven off from the slurry, pass from the kilns to exhaust flues leading to electrostatic precipitators, which extract the fine dust particles so that practically only steam and waste gases pass to the induced draught fans and on to the 300ft chimney. The fans have been developed to suit cement works practice and incorporate quickly detachable doors and segments of casing for the rapid cleaning or changing of the impeller, which can be done without interfering with adjacent flues. The impeller itself is attached by bolts to a flange on the shaft.

Each precipitator is divided into three chambers and the h.t. supply to the discharge electrodes is provided by two mechanical rectifiers, these arrangements being made to ensure that the dust emission from the chimney is at all times not more than 0·4 grains per cubic foot. The dust that is collected is returned to the kiln. The use of three electrode chambers enables any one to be shut down for cleaning and maintenance while leaving the other two in operation, so that it is unnecessary to wait for a kiln stoppage before giving attention to the electrode chambers. A by-pass is also provided whereby the kiln gases can be taken direct to the fan.

The instruments for controlling the operation of the kilns are grouped on a control panel on the firing floor, which contains the electrical controls for the driving motors, slurry feed and coal feed, temperature indicators and recorders, gas analysis meters and draught indicators.

The motors associated with the two kilns are operated from this control board, which is over 18ft long and is mounted on "Silentbloc" pads; it controls the following main motors: 170 h.p. kiln drives, 170 h.p. two-speed induced draught fans, 150 h.p. coal pulverisers, 50 h.p. coolers, auxiliary d.c. motors for the slurry spoon feeders and atritor feeds. In addition, the board has been designed to accommodate the various indicating and recording instruments, which give the kiln burner ready indication of the conditions prevailing. Flashing lights are mounted on the top of the board and are duplicated at the back end of the kiln to indicate that the cement slurry is being delivered to the kilns. In the event of a failure of supply, alarm is given by a hooter.

Mention should be made of the contactor switchgear controlling the two-speed, 170/52 h.p. induced draught fan motor. Provision is made for ensuring that the motor is started on the low-speed winding, and a time delay relay further ensures that the low-speed contactor remains for an adjustable starting period of 40–60 seconds, whilst another timing relay, adjustable from 0–30 seconds, is incorporated for the change from low to high-speed running.

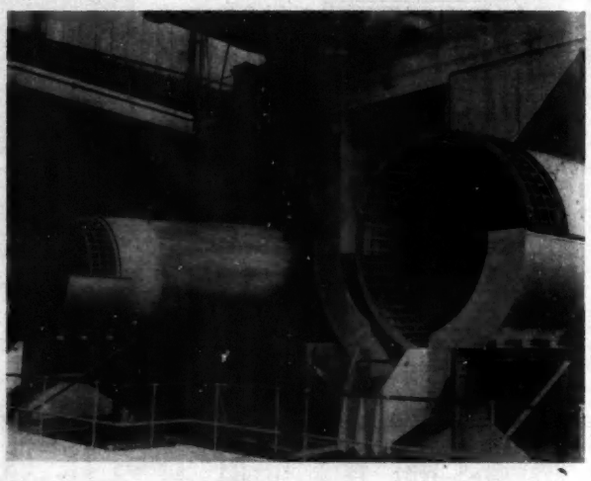
Clinker Handling and Material Stores

The ends of the coolers are formed with 6in mesh grids, the oversize material passing to a hopper bottom chute, from which it is periodically removed by barrow and deposited in the clinker crusher pit. The clinker passing through the cooler grids is carried along on shaker conveyors. Towards their discharge ends these shakers become double decked, the upper acting as a screen which separates the larger material and passes it direct to a pit. The undersize passes on to a belt conveyor leading to the clinker store. If this conveyor is stopped, the undersize also can go to the pit. Beyond the conveyor feeding the store is a further system by which clinker is fed direct into the grinding mill hoppers—this being the normal operation. The main clinker store, has a capacity of 15,000 tons, i.e., about two weeks' supply. The arrangement adopted has the advantage that all clinker in the main store is a suitable size for feeding to the grinding mills and also that large lumps are not fed on to the belt conveyors. These large pieces retain their heat and quickly damage the rubber belts.

Special dust-prevention chutes are used for the discharge of the clinker from the high-level conveyors to the store below. They are in the form of vertical steel cylinders with discharge ports at various levels. Only the ports just above the clinker level in the store are open so that there is no free drop of clinker in an open space. The dust formed inside the cylinder either settles or is extracted from the top of the cylinders to a dust plant.

Gypsum is brought by rail and reaches its part of the store over the same conveying system as the coal, using the same tippler and belt conveyors. Coal arrives by rail and is unloaded by a combined weighbridge and tippler into a hopper, beneath which a jigger feeder discharges to a 24in belt conveyor. This tippler is completely enclosed and a dust plant prevents the dust which rises from passing outside the building. A system of conveyors which incorporate an overband magnetic separator discharges either to the coal store or on to a

350ft Long Rotary Kilns



Kiln Coolers

vibrating screen which removes the +¾in to a crusher. Coal leaving the crusher discharges to the store while that passing the screen is transported in a Redler conveyor to the four 700-ton atritor coal hoppers. The coal store can hold 5500 tons of coal and is served by two electric overhead travelling cranes with 5-ton grabs. The cranes pick up coal when required and discharge it into a bunker which feeds a conveyor system connecting with that carrying coal direct to the screen, from which it travels as before to the atritors. At the point where the coal is either discharged direct to store or on to a screen, another conveyor is introduced which carries the gypsum to its own store, which has a capacity of 1500 tons.

The three stores—coal, clinker and gypsum—are all housed in the same long building, suitably partitioned, and served by the same overhead cranes. This building runs parallel and adjacent to the kiln building, an annexe between the two forming a suitable location for the distributing conveyors. This annexe also contains dust-extraction plants to dedust the various transfer points of the conveyors and other places which would create a dust nuisance. At one side of the clinker store are twin rows of hoppers for clinker and gypsum, used for feeding the grinding mills in the adjacent building.

Clinker Grinding

Below the clinker and gypsum hoppers are belt feeders equipped with weighing and constant-feed control gear. With this apparatus the feed rate of the material to each grinding mill can be set at the required amount and remains constant. Four grinding mills are installed, two 1200 h.p., one 800 h.p., and one 400 h.p. moved from the old works. This combination allows flexibility in utilising to the full the advantages of the "off-peak" clauses of the tariff for electric power.

All mills have central shaft drive and their motors and gearboxes are housed in a separate annexe of the mill building so as to be away from possible sources of dust. The gearboxes of the 1200 h.p. mills are equipped with barring gears and motors to facilitate maintenance work. They have pressure relay switches which automatically cut out the main drive motor if the pressure in the oil supply to the gears falls below a predetermined figure.

Each mill has its own reek-extraction plant and their shells are water cooled.

The 1200 h.p. mills are 8ft 4½in diameter by 45ft long divided into four compartments, giving chambers approximately 30, 20, 30 and 20 per cent of the mill length. They are fed through a 5ft 3in diameter, three-scroll drum feeder and hard alloy iron or chrome steel liners are used in the first two chambers and hard white cast iron in the third and fourth. The mills are driven at 20·5 r.p.m. clockwise viewed from the drive end.

The 800 h.p. mill is 7ft 6in diameter by 40ft long, divided into three compartments, giving chambers approximately 30, 40 and 30 per cent of the mill length. It is fed through a 4ft diameter, two-scroll drum feeder and the same lining materials are used as for the 1200 h.p. mills. The speed is 21 r.p.m. anti-clockwise viewed from the drive end. The 400 h.p. mill is 6ft diameter by 29ft 4in long, divided into three compartments. Its speed is 25 r.p.m., and it has been reconditioned. There is an eight-panel board controlling the mill motors.

The mills discharge into a system of Redler and belt conveyors which carry the cement and distribute it among the twelve storage silos, each having a capacity of 1250 tons. Redler conveyors are used to extract the cement from the silos and transport it to a 30in belt conveyor which elevates to the road bridge and discharges into two 900-ton silos adjacent to the packing plant.

Packing Plant

One of these 900-ton silos is used for ordinary Portland cement and the other for rapid hardening. Extraction from each silo is by aerating the cement in sloping channels, which discharge into a 24in screw conveyor. Each conveyor discharges into a cable chain central discharge elevator with a capacity of 125 tons per hour. Each elevator serves one of the two packing machines, its discharge entering a revolving trommel screen, which removes any air-hardened cement or foreign matter, that passing through falling into a surge hopper of 20 tons capacity. Beneath the surge hopper is a pneumatic feeder which contains air pipes and revolving members to ensure that the cement is thoroughly agitated and completely aerated, in which condition it flows like water. It now passes into the packing machine itself, a twelve-spout "Fluxo" with a maximum capacity of 120 tons per hour in hundredweight paper bags. The bags leave the packer on a laminated conveyor discharging on to a system of belt conveyors to the loading bays. The conveyors are arranged so that either packer can be used for ordinary or rapid hardening cement and also can deliver to either rail or road loading. In the restricted triangular site for the packing plant and sidings this required some ingenuity.

Three lorry bays are provided for road loading, each being served by a retractable boom conveyor, which takes the bags right up to the point on the lorry where they are loaded. Rail loading is done from a turntable situated on a platform between the two rail loading lines. Bags are delivered on to the table by means of an overhead chute from the conveyor system and are removed by a team of loaders working with barrows. Each loader removes about six bags on to his barrow and wheels them into a truck, where they are stacked. The average loading rate of the team is 100 tons per hour, whether to road or rail. Electric capstans are provided for moving the trucks as required. The packing and loading machinery is sequence interlocked so that should any unforeseen stoppage occur the associated equipment also stops and prevents a blockage.

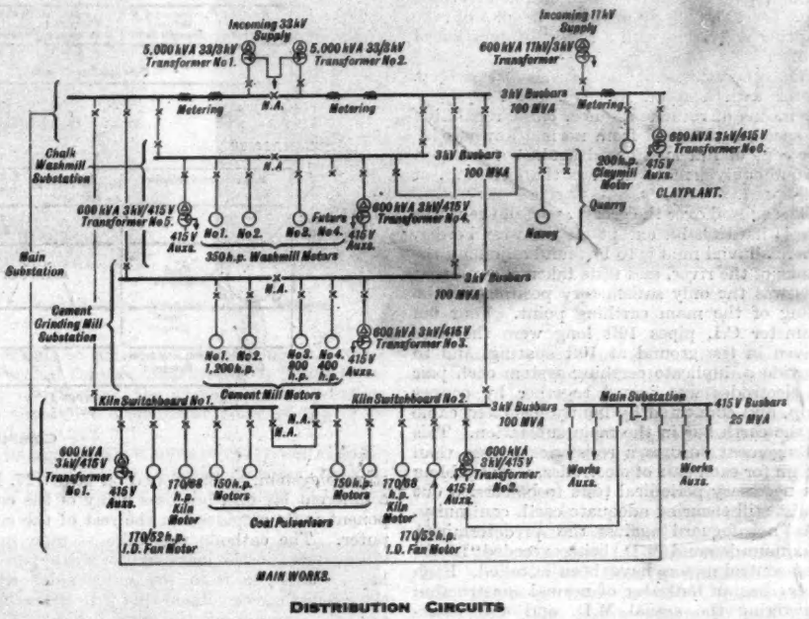
The works includes also a workshop block, extensive railway sidings and a water supply which is drawn from two boreholes.

Power Supply

The power supply to the works is afforded by duplicate 33kV lines of the South-Eastern Electricity Board's network. Two 5MVA, three-phase, delta/star O.N. cooled outdoor transformers step down the voltage to 3kV. These transformers are fitted with on-load automatic tap-changing equipment, which permit a voltage variation of plus 6 per cent to minus 9 per cent in ten 1·5 per cent steps. Protection on the 33kV line is taken care of by neutral point displacement with overload and earth leakage. Fault-throwing switches are incorporated, which, in the event of a fault, intertrip the 3kV transformer oil circuit breaker, preventing reclosure whilst the system is unhealthy. The clay quarry being approximately 3 miles from the main works, an 11kV supply is brought in by means of an overhead line "spurred off" the local S.E.E.B.'s ring main. One 600kVA, three-phase, delta/star O.N. cooled outdoor transformer steps down the voltage to 3kV. The supply of both works is metered by duplicate integrating watt-hour meters with maximum demand indicators. The total maximum demand when the works are in full production will be of the order of 5500kW.

In the manufacture of cement continuity of supply is extremely important, so that the 3kV feeder system is split and duplicate supplies are afforded to the various substations, as illustrated in the line diagram below, thus ensuring that under ordinary circumstances a local power failure cannot shut down both kilns.

The whole of the 3kV switchgear comprises some fifty-two single bus, air insulated, vertical plugging equipments, having a rupturing capacity of 100MVA. The feeder and transformer oil circuit breakers include spring closing, whilst for the 3kV motor circuits solenoid operation is employed.



DISTRIBUTION CIRCUITS

In the main substation there are three switchboards, comprising one fourteen-panel and two seven-panel boards. It will be noted from the line diagram that the incoming feeds from the two 5MVA transformers connect to the fourteen-panel switchboard, one on either side of a bus section switch, which, under normal operating conditions, remains closed. From this board outgoing feeders in duplicate afford supply to the two seven-panel kiln switchboards and also to the grinding mill and washmill substations, which have been mentioned earlier.

The transformers affording the l.v. supply (415V, three-phase, 50c/s, earthed neutral system) are of 600kVA capacity and are positioned at the various substations.

The principle of sectionalising the l.v. network to safeguard continuity of supply has been incorporated in all the main switchgear. A seven-panel airbreak truck switchboard of 25MVA rupturing capacity, with H.R.C. air circuit breakers, is positioned in the main substation. It controls the incoming feeders from the two 600kVA step-down transformers, two 2 by 0·25 square inch outgoing feeders to a main switchfuse board, one 2 by 0·25 square inch outgoing feeder to the packing plant, and one 2 by 0·15 square inch outgoing feeder to the kiln house, together with one 1200A bus section switch. The sub-distribution switchgear throughout the works comprises over twenty fuse switchboards, some with off-load isolators of 800/1000A capacity,

together with some seventy distribution boards.

About 200 oil-break starters have been supplied for the l.v. motors, which include direct-on-line units for squirrel-cage motors and stator/rotor units for slip-ring motors. The larger motors up to 1200 h.p. have rotor control by means of liquid starters.

All 3kV motors are protected against single phasing, overcurrent and earth leakage by thermal relays, together with direct-acting overload trip coils with fuses as back-up protection.

Motors

In order to obtain a satisfactory overall power factor, auto-synchronous induction motors incorporating pedestal mounted cartridge ball and roller bearings have been adopted for driving the large grinding mills. Two are rated at 1200 h.p., 970kVA, and one 800 h.p., 600kVA, designed to give a power factor of 0·95 leading.

All the 3kV motors are of the standard drip-proof pattern.

There are, however, two somewhat special drives associated with the kiln. One is that for the induced draught fan, which is an 8/12-pole machine with an output of 170/52 h.p. at 725/490 r.p.m., the weight of the impeller is 3700 lb with a radius of gyration of 2·62ft.

The other, the main kiln drive, is a 170/68 h.p. motor with a speed range of 592/230 r.p.m. By means of rotor resistance, close regulation of speed is obtained from normal down to 50 per cent of full load speed against a constant torque equivalent to not less than 150 h.p. at full speed.

The subsoil over the greater part of the works site is hard chalk, except on the west border, where alluvial mud is to be found adjoining the banks of the river, and tests taken showed that this was the only satisfactory position for the siting of the main earthing point. Four 6in diameter C.I. pipes 10ft long were therefore driven in the ground at 10ft spacing, and to provide a duplicate earthing system each pair of electrodes was joined together by copper strip, and connected by lightly insulated cable to the earth bar in the main substation. This arrangement ensures a resistance of less than 1 ohm for each pair of electrodes, thus enabling the necessary periodical tests to be carried out whilst still ensuring adequate earth continuity.

As a safeguard against the predetermined maximum demand (M.D.) being exceeded "Ideal" load-control meters have been installed. Each meter has an indicator of normal construction registering the actual M.D. and also incorporated is a second M.D. indicator which is driven by a synchronous motor at a speed proportional to the value of the predetermined M.D. Should the actual M.D. exceed that corresponding to the setting of the predetermined load, except within the first three minutes of each (thirty minutes) period, then a contact device closes enabling audible or visual warning to be given to the load controller.

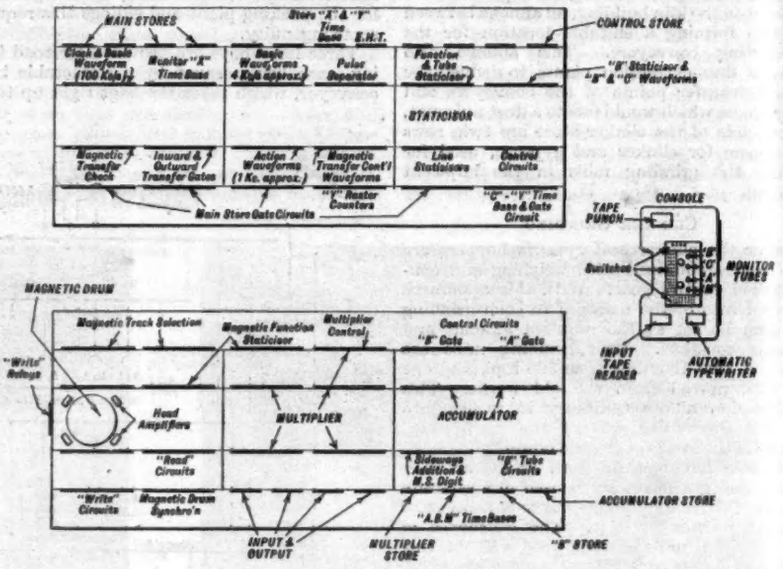
The Shoreham works were designed by the staff of the Associated Portland Cement Manufacturers, Ltd., who were also responsible for the design of the washmills and many of the kiln details and other equipment. The consulting engineers for the civil engineering work were Oscar Faber and Partners, and the main contractors were John Laing and Son, Ltd. The sub-contractors for reinforced concrete were Bierrum and Partners and for the structural steelwork, Redpath Brown and Co., Ltd. The main contractors for the mechanical handling plant were the Mitchell Engineering Company, Ltd., and for the civil engineering work for the clay plant, J. L. Kier and Co., Ltd.

GAS TURBINE COURSES.—Power Jets (Research and Development), Ltd., has now issued a programme of courses to be held at the School of Gas Turbine Technology, Farnborough, Hampshire, for the period August 19, 1951, to May 30, 1952. The post-graduate courses for British or Commonwealth students on gas turbine design provide for both aeronautical and industrial plant and are of two and three-week duration. There is also a practical aero-engine course open to students of any nationality.

The Automatic Digital Computer at Manchester University

No. III—(*Continued from page 93, July 20th*)

THE general lay-out of the computer installation is shown in the diagram and the first of the photographs reproduced herewith. It will be seen that the main apparatus, apart from the control console, is arranged in two bays, each 16ft long, 8ft high and 4ft wide, and each consisting of three cabinet sections. Five of these sections are mechanically identical; the sixth, which houses the magnetic chassis, which will accommodate a total of eight pentode valves (such as "EF50" or "EF55"), twenty-nine diodes, such as "EA50," nine neon tubes for indication purposes, a heater transformer, and sixty-six components. As shown in two of the illustrations on page 127, these chassis are mounted on hinged cast alloy doors, which are of two sizes. The larger doors, which accommodate six chassis each, are



COMPUTER LAY-OUT

storage system, as illustrated on page 127, has a different lay-out, but uses many of the component units employed in the rest of the computer. The cathode ray tube storage units are mounted in the lower half of the apparatus bays, accessible from the outer side, while the circuits directly associated with the cathode ray tube stores are on the inward side.

With the exception of a few special units, all the electronic circuits are built on standard fitted on the upper half of the computer. The smaller doors, which carry four chassis each, are used on the lower part of the equipment. An important practical point is that the fixing centres for these chassis are the same as for standard G.P.O. racks: ordinary rack mountings can therefore be used for testing and experimental work.

All the leads from each group of chassis are terminated on Plessey "quick release" ter-

DIGITAL COMPUTER INSTALLED AT MANCHESTER UNIVERSITY

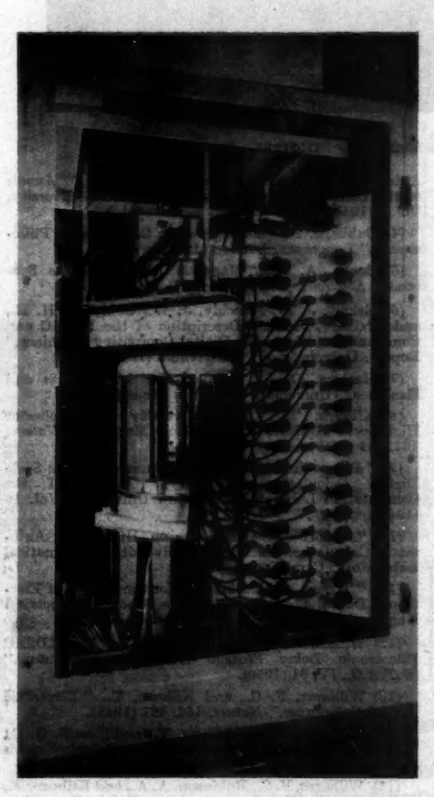
APPARATUS RACKS AND WIRING

minal blocks, which are mounted on the doors, as illustrated. Flexible leads are taken from these terminal blocks to the vertical ducts, where they are run into a terminal board next to the horizontal duct. The horizontal ducts occupy a position corresponding to the keyboard of an upright piano and they separate the upper and lower sets of racks. Each horizontal duct contains eighty air-spaced pulse leads. All the necessary connections between the racks and the required routing of the pulses is achieved in the wiring between the horizontal and vertical ducts on each rack.

The magnetic storage drum, which has been referred to previously in this article, is shown in one of the accompanying illustrations. The drum is 6in in diameter and 8½in long, and the cylindrical surface is nickel-plated to provide a recording area upon which it is possible to store 655,360 digits. On the drum there are 256 separate recording tracks, each of which has its associated recording head. For recording purposes, the drum is required to have a high degree of concentricity and in practice the error in the drum has been limited to an eccentricity of not more than 0·0003in. Normally the drum is designed to run at a speed of 1950 r.p.m. under the control of an electronic position servo mechanism, which limits the positional error at any time to 1 part in 36,000, or 0·01 degree. This order of accuracy is achieved by keeping the inertia/friction ratio as high as possible and by carefully balancing the drum: in operation the time required for the drum speed to run down from 2000 r.p.m. to standstill is more than thirty minutes.

The power input to the computer (which contains 3500 valves, twelve cathode tube stores, in addition to 15,000 resistors and 2500 condensers), is 27kW and a forced ventilation system is required to dissipate the heat losses. Ventilation is carried out by blowing 3600 cubic feet of air per minute into the computer room and extracting 3000 cubic feet of air per minute from the computer, via the trunking, which can be seen in one of our illustrations. By maintaining an excess of intake over outlet air it is possible to ensure that only filtered input air is drawn through the computer itself. As far as ventilation is concerned, the computer can be regarded as consisting of a series of vertical funnels, and cooling is found to be very satisfactory, the average air temperature rise through the computer being of the order of 10 deg. Cent.

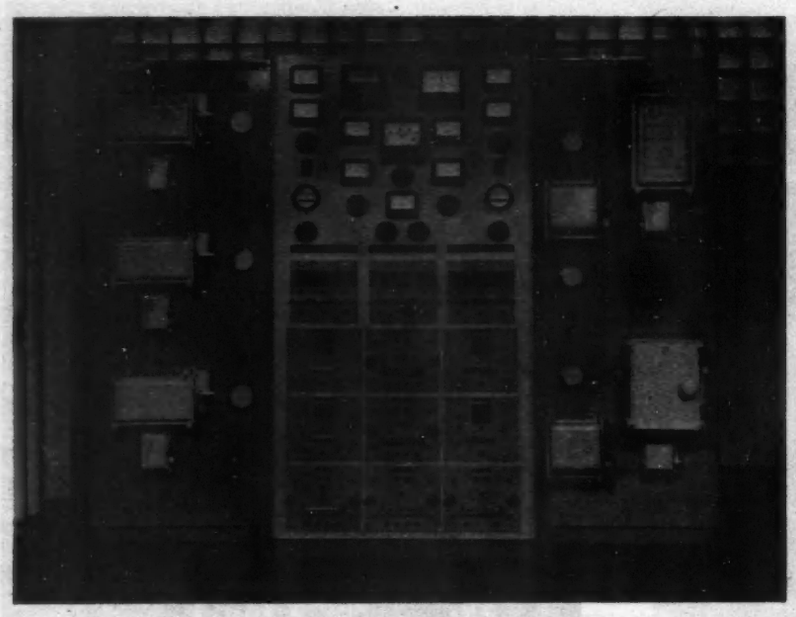
Throughout the computer the power supplies are carried on substantial busbars running along the top of the racks (as shown in the left hand illustration) and are brought into each of the hinged apparatus racks through fuses and flexible connections. There are seven d.c. supplies and one a.c. supply to the machine and the relevant instrument and control panel is illustrated overleaf. The three main d.c. supplies are 300V, 200V and—150V, each rated at about 14A. The other four d.c. supplies are low current supplies with a rating of about ¼A. All the supplies are obtained from motor generator sets, the basic reference supplies being derived from a stabilised power pack operated from a 400V, three-phase alternator. The motor generator sets that provide the remaining supplies are electronically stabilised and, in the case of the three heavy current d.c. sources, electronically smoothed. Voltage variation and ripple on the d.c. supplies has been reduced to less than ¼V. Current for the valve heater circuits is derived from a motor-alternator set with an output of 115V, 70A, 1600 cycles per second. The reason for choosing a high frequency for this supply source was to allow smaller heater transformers to be used on every chassis throughout the computer so that there was no need for heavy current low voltage supplies to be carried round the eqipment. Provision is made whereby the heater voltage can be raised steadily over a period of approximately 1½ minutes after switching on to the stabilised a.c. supply.



MAGNETIC STORAGE DRUM

At the press preview of the computer at Manchester University, on July 6th, a brief demonstration of the equipment was given. The demonstration was in two parts. For the first part the machine was set up with a demonstration programme for calculating a table of squares of the first n natural numbers, n being 100 in this instance. This programme was chosen because it makes use of most of the facilities of the computer and involves the carrying-out of 500 instructions. All but twelve of these facilities are used to make the programme fully self-checking and automatic, and to set out the answers in decimal form in form columns.

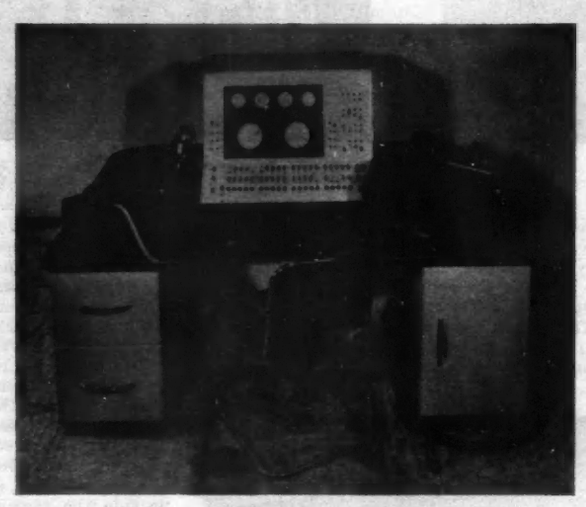
The second part of the demonstration was designed to show the self-checking properties of the computer, whereby the carrying out of



POWER SUPPLY CONTROL PANEL

every instruction is automatically checked and the incidence of a fault initiates a test routine, which automatically determines the part of the computer containing the faulty component. This property of the machine was demonstrated by the removal of a valve to simulate a random fault.

An inaugural conference covering various aspects of the computer was held in the University of Manchester from July 9th to 12th, when many of the individuals who have been responsible for the design and engineering of the computer were in attendance. The first session was concerned particularly with the Manchester University computer built by Ferranti, Ltd. Discussions on the engineering aspects of the computer were introduced by Professor F. C. Williams and Dr. T. Kilburn; the mathematical aspects of the equipment were then dealt with by Mr. A. Turing and by Professor M. A. Newman. During the second session (July 11th) other projects besides the Manchester University computer were the subject of discussion introduced by Dr. M. V. Wilkes, Mr. M. Woodger and other speakers. The third session (July 12th) was arranged by Ferranti, Ltd., and included a discussion on scientific and commercial trends in computer requirements introduced by Dr. B. V. Bowden; a discussion on machine reliability from the engineering and user viewpoint introduced by Dr. A. A. Robinson, and a discussion on handling of structural engineering and power distribution problems, introduced by Mr. J. M. Bennett.



CONTROL DESK OF DIGITAL COMPUTER

In conclusion, it will be appreciated that a detailed description of the computer or its applications is outside the scope of this article. The following list of references, however, although by no means exhaustive, may serve as a guide to readers who wish to pursue the subject further.

REFERENCES

(1) Williams, F. C., and Kilburn, T., "A Storage System for Use with Binary Digital Computing Machines," *Journal*, I.E.E. 96, 81 (1949).

(2) "A Discussion on Computing Machines," "Proc." Roy. Soc., 195, 265 (1948).

(3) Aiken, H. H., "A Manual of Operation for the Automatic Sequence Controlled Calculator," *Annals* of the Computation Laboratory, Harvard University, Vol. I (1946).

(4) Babbage, C., "Passages from the Life of a Philosopher," Longmans, London (1864).

(5) Booth, A. D., "Magnetic Digital Storage Systems," *Electronic Engineering*, 21, 234, (1949).

(6) Eckert, J. P., Mauchly, J. W., Goldstine, H. H., and Brainerd, J. G., "Description of the ENIAC and Comments on Electronic Digital Computing Machines," Report, University of Pennsylvania (1945).

(7) Hartree, D. R., "Calculating Instruments and Machines," University of Illinois Press (1949).

(8) Kilburn, T., "The University of Manchester High-Speed Universal Computing Machine." *Nature*, 164, 684 (1949).

(9) "Proceedings of a Symposium on Large-Scale Digital Calculating Machinery," *Annals* of the Computation Laborstory, Harvard University, Vol. 16 (1949).

(10) "Report of a Conference on High-Speed Automatic Calculating Machines," University Mathematical Laboratory, Cambridge (1950).

(11) "Theory and Techniques for the Design of Electronic Digital Computors," Moore School of Electrical Engineering, University of Pennsylvania (1947).

(12) Wilkes, M. V., and Renwick, W., "The EDSAC (Electronic Delay Storage Automatic Calculator)," *M.T.A.C.*, IV, 61 (1950).

(13) Williams, F. C., and Kilburn, T., "Electronic Digital Computors," *Nature*, 162, 487 (1948).

(14) Williams, F. C., Kilburn, T., and Tootill, G. C., "High-Speed Digital Computors—A Small-Scale Experimental Machine," to be published in "Proc.," I.E.E.

(15) Williams, F. C., Robinson, A. A., and Kilburn, T., "High-Speed Digital Computors—Serial Computing Circuits," in preparation.

American Engineering News

(From our American Correspondent)

Flight Refuelling of Fighter Aircraft

The Republic Aviation Corporation, of Farmingdale, New York, has announced the production of its first operational jet-propelled fighter aircraft equipped for mid-air refuelling by tanker planes. The new aircraft is known as the "F-84 G" and has a longer range and a faster climbing ability than the Republic "F-84 E." The refuelling system of the "F-84 G" aircraft is designed for use with the Boeing "flying boom" method of flight refuelling. In accordance with this method, an operator in the tail of the tanker aircraft operates a telescoping boom with directional control surfaces to guide the boom into the wing receptacle of the close-flying fighter. Once the boom nozzle engages the fighter, fuel transfer becomes automatic. Complete refuelling can be accomplished within two and a half minutes with fuel passing to the fighter aircraft at a rate of several hundred gallons per minute. For pilot comfort and efficiency during long-range flight operations, the new fighter-bomber is equipped with an automatic pilot. The improved Allison power plant of the "F-84 G" aircraft delivers 5600 lb thrust or 10 per cent more than that which is available in previous engines of this same model. The company also reports that additional thrust has been obtained through the redesign of the "F-84 G" ejector. Production of the "F-84 G" aircraft has now been in progress for several months, but the number completed is not being disclosed. The new model will eventually replace production of the "F-84 E" aircraft, and will be delivered to fighter wings of the U.S. Air Force and to countries participating in the Mutual Defence Assistance Programme.

A Large Vertical Boring Mill

The Baldwin-Lima-Hamilton Corporation, of Hamilton, Ohio, recently completed a Niles vertical boring and turning mill which is said to be the largest machine of this design ever built in the United States. The machine has a maximum swing of 43ft 5in, a table 33ft in diameter, and a maximum height under the tools of 12ft 2in. It has a total length, over the operator's platforms at each end of the cross rail of 65ft, a total height of 25ft, a bed extending 9ft 6½in below the top of the table, and a weight of 570 tons. It is being delivered to Italy, where it will be used primarily for turning generator and turbine parts for hydro-electric installations. The table is 3ft thick and is made in three sections to facilitate transport. It is rotated by a 20 deg. helical gear approximately 24ft in diameter. This gear has 288 teeth of 1 diametral pitch and is cast in halves, which are joined on the 20 deg. helical angle. A wide track of large diameter, flooded by oil under pressure, provides support for the table, which is driven by two pinions placed 180 deg. apart. The pinions, in turn, are driven by two d.c. motors of 50 to 75 h.p., which are balanced electrically to equalise the drive. Back gears built into the drive mechanism of each motor provide a table speed range of 0·125 to 5 r.p.m. The back gear clutches are shifted simultaneously by electric motors operated by control buttons. The drive motors and all drive shafts are vertically mounted and run on anti-friction bearings. A 30 h.p. motor on the cross brace drives four vertical screws which elevate the cross rail. Four ¾ h.p. motors clamp the cross rail to both the inside and outside of each housing. Elevating and clamping mechanisms are electrically interlocked. The forged steel octagonal boring bars measure 12in across flats and have a travel of 9ft. These bars slide on renewable bronze plates. Sixteen mechanical feeds are provided for traversing the saddles along the cross rail or for traversing the bars vertically or at any angle up to 30 deg. either side of the vertical position. Feeds range from 0·01mm to 32mm per revolution of the table, and are obtained from the drive on each side of the machine. Power rapid traverse to each bar and saddle is provided by 10 h.p. motors at the rear of each end of the cross rail. Selection between bar and saddle and between feed and

rapid power traverse is made by levers on the heads or at the ends of the cross rail. The bars and saddles can be adjusted manually by automatically releasing hand ratchets, which can be operated at any position between the end of the cross rail and the saddle. Direct-reading micrometer dials, graduated in sixteenths and thousandths of an inch, are mounted on the heads for the bars and saddles. Safety friction clutches in the feed and traverse mechanism prevent breakage if the heads are run together or the bars are run against the work. The bars are electrically clamped when the saddles are being fed, and the saddles are electrically clamped when the bars are being fed. Operator's platforms are provided on each head, at each end of the cross rail, at the rear of the cross rail, and on the cross brace. Lubrication of all running ports is automatic. A 150kW d.c. generator, driven by a 250 h.p. a.c. motor, provides power for the d.c. motors.

Non-Ferrous Scrap Prices

FOLLOWING increases in the prices of virgin lead and zinc, the Minister of Supply has made an order increasing the maximum prices of the classes of non-ferrous scrap and secondary metal which contain the two metals. The order brings brass ingots and billets under price control for the first time, and, in addition, it redefines remelted lead, and reduces the price for clean bright untinned copper wire and commutator bar.

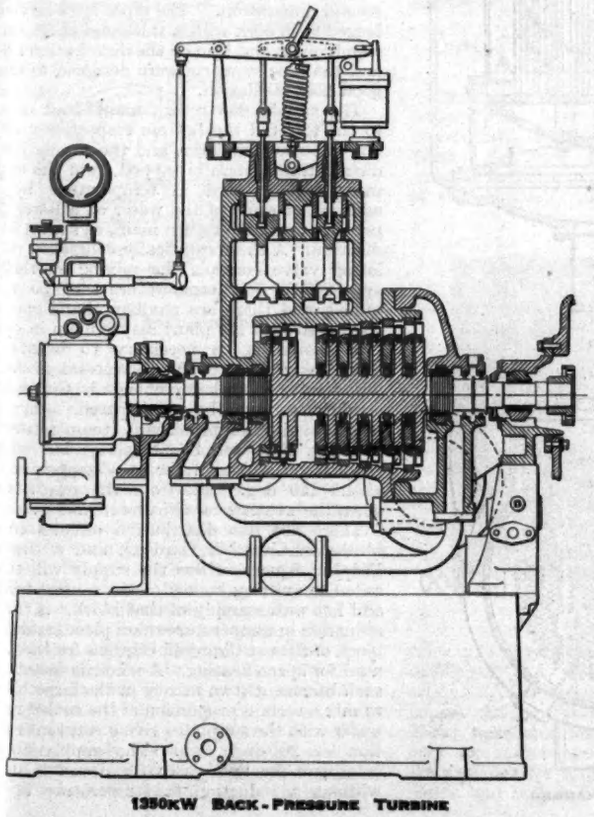
Amongst the new prices stated are: lead (remelted containing by weight not less than 96 nor more than 99·96 per cent lead), £165 per ton; lead scrap (cable sheathing), £165 per ton; zinc (remelted), £181 per ton; zinc (to B.S.S. No. 1141), £204 per ton, zinc (cuttings), £161 per ton; zinc (alloy scrap die castings free from inserts), £181 per ton; brass (70/30 strip ingot for rolling), £243 per ton; brass (to B.S.S. 218 or 219, cropped billets), £234 per ton; brass (65/35 casting quality), £229 per ton; copper scrap (clean), £217 a ton; Admiralty gunmetal scrap (in any form not less than 9 per cent tin and not more than 0·5 per cent lead), £263 a ton; commercial gunmetal scrap in any form, £225 per ton; cupro-nickel scrap (70/30 process scrap), £257 a ton.

District Heating at Pimlico

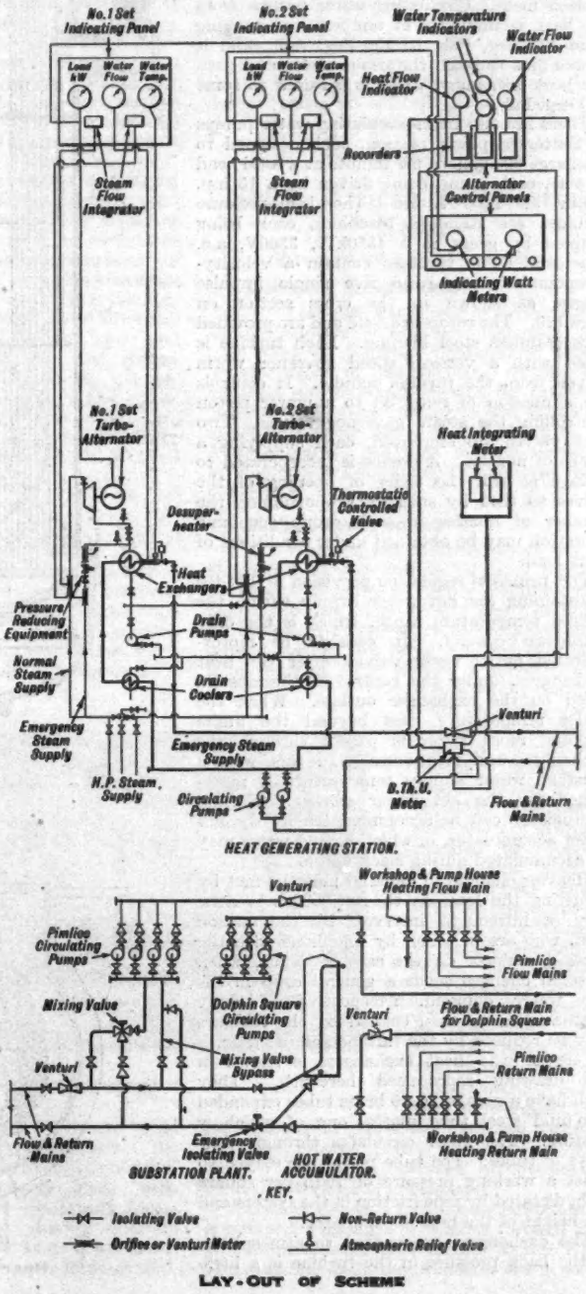
ON Tuesday last, July 24th, the estate known as Churchill Gardens, on the north bank of the River Thames at Pimlico, was opened by the Duchess of Marlborough. The estate consists of a number of blocks of flats, some of which are still under construction, which are heated by a district heating supply derived from turbo-alternators in Battersea power station. The first part of this district heating plant went into operation early this year to supply hot water for space heating and domestic use to some of the new blocks; the district heating installation is also intended to supply the existing large block of flats at Dolphin Square. It is said to be the first public heat supply in the country to make use of combined thermal electric generation. This system of heat electricity supply was described in THE ENGINEER of March 17 and 24, 1950.

The source of heat for the scheme consists of two 1350kW back-pressure turbo-alternators in Battersea power station. The exhaust steam from these two machines is led to heat exchangers, whereby the water for the district heating, which circulates in a closed circuit, is raised to a temperature of up to 200 deg. F. The 12in diameter supply and return mains from the heat exchangers lead under the Thames through an existing tunnel of the Metropolitan Water Board, and thence to a distribution substation with a hot water accumulator. The accumulator is capable of storing about 400 million B.Th.U., the hot water being pumped to the top of it and the cooler water at the base being returned to the heat exchangers. The various distribution mains lead from the substation to the different hot water systems in the blocks of flats, the hot water for domestic use being provided by calorifiers. The function of the hot water accumulator is to balance the variation of the heat and electricity loads. It thus renders the operation of the system more flexible and ensures that the installed capacity of the back-pressure sets may be regarded as firm power.

Heating in the flats is designed to give a temperature of 65 deg. Fah. in living rooms and 60 deg. in other rooms when the outdoor temperature is 30 deg. Fah. The hot water supply was based on a demand of 15 gallons daily for each person at 130 deg. Fah. These assumptions indicated that the maximum heat demand on the system during a cold day would be 45 million B.Th.U. per hour for the Churchill Gardens estate (which will eventually contain 1600 dwellings) and 28 million B.Th.U. per hour for Dolphin Square (with 1220 flats), the number of people served eventually being



1350kW BACK-PRESSURE TURBINE



LAY-OUT OF SCHEME

nearly 10,000. The two back-pressure sets would each supply up to 23 million B.Th.U. per hour in that period and the remaining 27 million B.Th.U. per hour, necessary to meet the total load of 73 million, would be supplied during the day from the hot water accumulator and made up during the night. The thermal efficiency of the combined heat-electric generation is of the order of 80 per cent. Our illustration on page 130 shows diagrammatically the lay-out and instrumentation at Battersea power station above and the arrangement at the Pimlico sub-station below.

Back-Pressure Turbo-Alternators

The two back-pressure sets are each designed for an output of 1350kW and 23 million B.Th.U. per hour at a pressure of 2 lb per square inch (gauge). The initial steam conditions are 600 lb per square inch (gauge) at 800 deg. to 850 deg. Fah.

Two heat exchangers are provided, one to each turbine, arranged as vertical condensers. The condensate from the exchangers passes through drain coolers, one to each heat exchanger, and thereby increases the temperature of the circulating water entering the exchangers by 3 deg. to 5 deg. Fah. The cooled condensate is then extracted by motor-driven pumps and discharged directly into the boiler feed pump suction main. Circulating water returns from the heat accumulator at temperatures ranging from 110 deg. Fah. to 130 deg. Fah., and it passes first through the drain cooler and then the heat exchanger, where it is raised to some 200 deg. Fah.

There are two main circulating water pumps in Battersea power station, each designed to discharge 690 gallons per minute at a total head of 50ft, each pump being driven by a 15 h.p. motor at 1460 r.p.m. The back-pressure turbines are standard machines, each being coupled by gears to a 1350kW, 3300V, a.c. generator. The turbines contain a velocity-compounded stage and five single impulse stages, as shown in the cross section on page 129. The rotors are solid and are provided with stainless steel blading. Each turbine is fitted with a vertical speed governor worm driven from the turbine spindle. It controls the admission of relay oil to a power piston controlling the steam governor valves. Two such valves are employed, each supplying a group of nozzles. A device is incorporated to change at will the order of opening of the valves so that by suitably proportioning the number of nozzles in each group economic operation may be obtained under conditions of light load.

The principal regulating provision is that for maintaining the hot water supply within the desired temperature range, which is the only automatic control. It consists of motor-operated outlet water valves, after the heat exchangers, under the control of thermostats fitted on the exchanger outlets. When the outlet temperature rises beyond the limits imposed more water is passed through the exchangers and vice versa. In this way a constant water supply temperature is maintained for the hot water storage. Normal fluctuations can be accommodated by the hot water accumulator, in which heated water may be accumulated during slack hours.

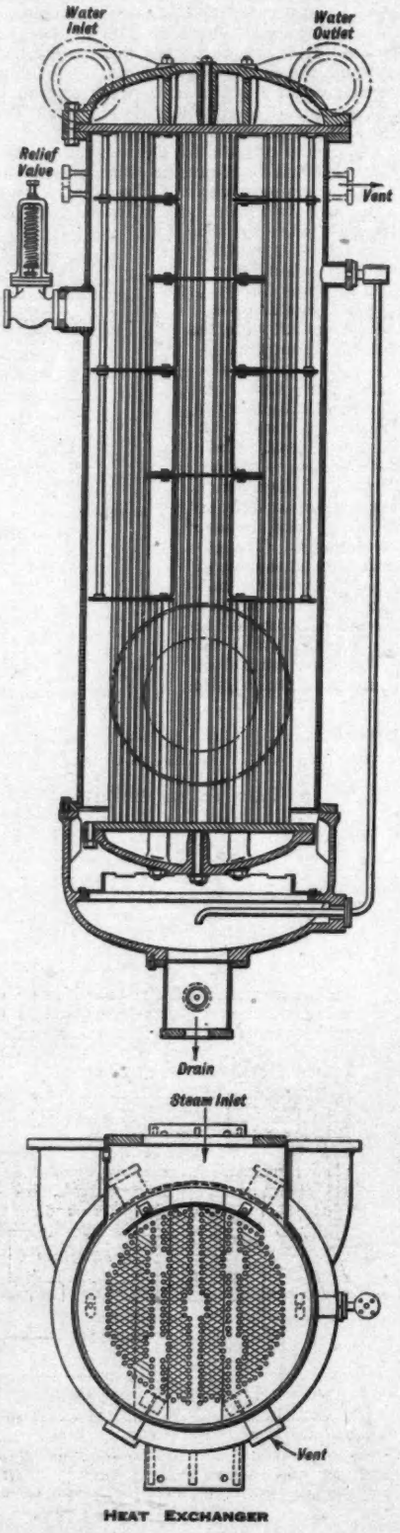
Heavier changes in demand must be met by adjusting the load on the set. This is done only at infrequent intervals by the station staff, who are in touch by telephone with the heating engineer on the estate. Thus, when seasonal changes cause a general drop in the hot water demand, irrespective of daily fluctuations, the load carried by the turbines may be reduced by the turbine speeder gear.

One of the heat exchangers is shown in the drawing reproduced herewith. They each have a nest of 70/30 brass tubes expanded into mild steel tube plates, one of which is floating. The water circulates through four flows of tubes. The tube plates are stayed to resist a working pressure of 70 lb per square inch, dictated by pipe friction in the system and the height of the heat accumulator.

The exchangers are vented to atmosphere, so the back pressure in the turbine is a little above atmospheric at full load. At light load there is a surplus of condensing surface and therefore a possibility of partial air pressure existing at the top or vented end of the tube nest.

In order to secure deaerated condensate under all conditions of operation the steam enters at the bottom of the vessel and thus always maintains zero partial air pressure at the base of the tube nest. An additional vent from beneath the bottom water header to a point of lower pressure near the atmospheric vent ensures a deaerating atmosphere in the immediate vicinity of the condensate discharge.

The heat produced by the fuel consumption required for one turbo set is approximately



HEAT EXCHANGER

362 therms per hour, from which 1330kW net is delivered to the busbars and 240 therms per hour is transferred to the circulating water of the heating system. To generate this electrical output of 1330kW with normal condensing turbine plant would involve the expenditure of some 170 therms per hour of heat in a boiler furnace, so that the 240 therms per hour transmitted to the heating system may be said to have been obtained for an additional fuel consumption equivalent to the difference between 362 and 170 therms, i.e., 192 therms per hour; moreover, the fuel is of the lowest grade.

The following figures have been put forward to show that this system compares favourably with a heat pump using circulating water discharge as a heat source. Assuming the circulating water temperature to be 65 deg. Fah. in cold weather, a motor-driven heat pump producing 240 therms per hour at 200 deg. Fah. would consume power equal to 345 therms per hour of heat from the power station fuel. If the equivalent heat for the electrical power of 1330kW, i.e., 170 therms per hour, is added, a total of 515 therms is obtained, compared with the total of 362 therms in the scheme adopted. Even if the temperature of the heat produced by the heat pump was reduced from 200 deg. Fah. to 140 deg. Fah., then the power absorbed by the heat pump would correspond to 210 therms per hour. But as the back-pressure steam system would produce more power if the back pressure were reduced to correspond to a water temperature of 140 deg. Fah., the fuel heat equivalent of the electrical load would be somewhat in excess of 170 therms per hour, making a total of over 380 therms per hour for the consumption of the comparable heat pump.

Substation and Distribution

The 12in diameter supply and return mains pass under the Thames through an existing tunnel of the Metropolitan Water Board, as was mentioned above. The tunnel is built of bolted cast iron segments and there are two water mains running along the bottom of it. The hot water pipes were therefore installed in the upper part of the tunnel. A tunnel was built to accommodate the pipes between the end of the M.W.B. tunnel and the substation on the Pimlico estate. The lay-out at the substation of the supply and return mains and their connection to the heat accumulator and the distribution mains are shown in our second illustration. The pipes are everywhere lagged with cork with a thickness of 2in on the supply main and 1½in on the distribution mains, and the pipe supports were designed to ensure good heat insulation.

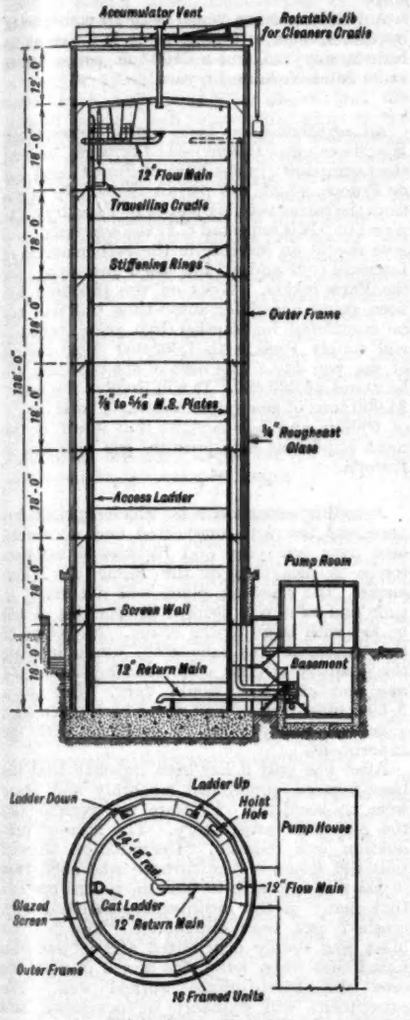
The supply and return mains lead directly to the top and the bottom respectively of the hot water accumulator, and the supply for the distribution system is tapped from the supply main and reduced in temperature by the addition of some of the water at a lower temperature from the return main, as shown in the diagram. A thermostatically controlled modulating valve controls the mixing so that an appropriate flow temperature can be maintained, and there are auxiliary hand-operated valves, so that the plant may remain in operation should it be necessary to isolate the modulating valve. The thermostat is set by an operator so that any change in the weather conditions may be anticipated. In cold weather the supply main temperature of 200 deg. Fah. will be necessary, but will be reduced by adding water at a temperature of about 130 deg. Fah. from the return main when the weather conditions are milder.

There are five distribution circuits to the blocks in Churchill Gardens, and a sixth to Dolphin Square, where the supply will supersede the existing boilers of the central heating and hot water supply of that block. A further reduction in temperature takes place inside each block of flats at Churchill Gardens for the water used for space heating. A mixer is installed in each basement (two mixers in the large blocks) to mix a certain proportion of the cooled return water with the supply to give a constant reduction of 20 deg. Fah. The supply to the calorifiers for hot water for domestic use is without a reduction in temperature at this

stage, however, so that the minimum temperature of the hot water from the taps is 130 deg. Fah.

Heat Accumulator

The accompanying illustration shows the hot water accumulator, which is a cylindrical tower, 126ft high and 22ft in diameter. It is built of welded mild steel plates, ½in thick at the base and $\frac{3}{16}$in thick at the top, and is insulated with a 3in layer of cork. Water is stored at atmospheric pressure, and the tank also acts as an expansion chamber for the circuits. The structure of the tower itself, which consists of a steel frame covered with glass, stands about 3ft clear of the tank, thus providing some additional insulation and space for access.



HEAT ACCUMULATOR

The design of the tower is of pleasing appearance and harmonises well with the other buildings of the estate.

One of the main problems of a combined heat and electricity supply is caused by the variation of heat and power loads. The heat accumulator is intended to even out the peak demands, thus allowing continuous generation of electric power at a substantially constant level. As the demand for heat during a peak period increases the flow of hot water will be drawn into the distribution circuits from the supply main, shown in the substation diagram, until the demand exceeds the rate of supply along the supply main. Additional water at the supply temperature will then be passed into the distribution system from the top of the accumulator and replaced at the bottom by water at the lower temperature from the return main. When the heat supply exceeds the demand the reverse process will take place and a store of thermal energy will be built up in the accumulator. There is a safety valve on the return main from the accumulator, which automatically closes if the water level falls unduly. Similar precautions will guard against faults in the mains, should the water level rise too far in the sump of the substation pump room or in the invert of the tunnel.

Distribution System and Metering

The flow and return mains of the distribution system pass along the basement of each block as a measure to reduce heat losses, the pipes being butt welded. The pumps are situated in the substation. The supply is not generally metered, a uniform charge being made to tenants, which in the case of a three-bedroomed flat is 8s. per week, and which it is hoped to reduce as the scheme develops. Provision is being made for the installation of portable heat meters in some of the blocks if this measure is required by the Ministry of Local Government and Planning.

There are heat meters in the power station to record the quantity of heat sent out, and the temperatures of the supply and return mains are continuously measured. This process is also carried out at the substation, and the temperature of the accumulator is measured at six levels. The supply to Dolphin Square will be measured, and a charge based on radiator area and time of use will be used for supply to buildings other than flats.

At present only one of the two back-pressure sets is in operation, and heat is being supplied to three blocks. It is expected that by the autumn of this year half the final heat demand will be supplied. Provision has been made for the installation of a third heat exchanger at Battersea power station at a later date.

The district heating consultants for the Pimlico scheme are Messrs. Kennedy and Donkin, and the consulting heating engineers Messrs. J. Roger Preston and Partners; the civil engineering work is under the direction of Messrs. Scott and Wilson and the architects are Messrs. Powell and Moya. The main contractors are the Metropolitan-Vickers Electrical Company, Ltd. (turbo-alternators and heat exchanger), J, Jeffreys and Co., Ltd. (transmission and distribution pipework, pumps, &c.), Whessoe Ltd. and Dawnays Ltd. (heat accumulator), G. N. Haden and Sons, Ltd. (systems in blocks and Dolphin Square circuit), and Holloway Brothers (London), Ltd. (civil engineering).

A Mobile Hospital

The mobile hospital shown in the illustration herewith has been supplied to the Pakistan Government by Petbow, Ltd., Richborough Works, Sandwich, Kent, to provide modern surgical facilities to outlying and remote parts of that country. The unit is to serve as a prototype from which several others are to be developed and ultimately dispatched. An articulated lorry chassis is used and the hospital houses an operating theatre, fitted with X-ray apparatus and other equipment necessary for major operations. Living quarters are provided for a doctor and two male attendants, and built-in fuel and water tanks, pump, filter and refrigerator units enable the outfit to cruise for weeks without recourse to town supplies. For the treatment of minor complaints and for dispensing an ante-room and outside bench and awning are incorporated. The electricity supply is provided by a mobile diesel-driven generating plant towed behind the main unit. This mobile hospital has a total weight of 7 tons.

A MOBILE HOSPITAL

Clip Valves

We have received details from Warren, Morrison, Ltd., 29, Bury Street, Westminster, S.W.1, of improvements to its range of valves. These valves depend upon the well-known laboratory clip principle and use a flexible tube, usually of rubber, with end flanges, which form the pipe joints and ensure the isolation of the fluid from the metal body. The metal body and closing mechanism are designed to support the tube, which, therefore, becomes a flexible lining and does not have to withstand the fluid pressure over more than very small areas. On 1½in and smaller valves closing is from the top only and on 2in and larger valves closing is from top and bottom of the tube. All spindles have multi-start square threads; when required, rising spindle valves can be supplied. Designs are in hand for quick-acting and remote control operation.

The valve offers little flow resistance and provides control down to shut off whilst, due to the isolation of the fluid in the renewable rubber tube, it will handle corrosives and abrasives as well as clear neutral liquids.

South African Engineering News

(From our South African Correspondent)

Increasing Mineral Output

Last year was a year of records for the mining industry of Southern Rhodesia. The total value of minerals produced in 1950 is of the order of £13,500,000. Of the base minerals, asbestos will account for two-thirds of the output. The tonnage of coal (2,345,841) raised at Wankie last year was also a record. A newcomer to the base mineral market is beryllium from Fort Victoria, which was valued at £55,623.

Shabani Power Station

Work on the construction of the new £1,000,000 power station of the Southern Rhodesian Electricity Supply Commission at Shabani is now in progress. The foundations for the power-house, which are adjacent to the present station, are being laid and excavation is in progress. The project is expected to be completed by the end of 1952, and will comprise two 5MW generators powered by two high-pressured boilers, each with 50,000 lb to 60,000 lb evaporation per hour. Although planned to supersede the original plant, it would appear that at first the new plant will operate in addition to it, as the demand for power has increased tremendously with the boom in asbestos mining in this area. Since the Electricity Supply Commission first produced electricity at Shabani in November, 1939, the demand for power has increased threefold, and the present plant, consisting of three 3750kW generators operated by low-pressure boilers, is working to full capacity.

The water required for the new power station is pumped a distance of 9 miles through a 6in pipe from a large pool on the Lundi River. The station's daily requirements are in excess

of 250,000 gallons, and a second 6in pipe-line is in process of installation. The construction of two dams on the river, which was completed in time to fill with the first floods in December last, will ensure adequate water supply for all requirements.

Crude Oil Distillation Factory

Plans for the manufacture, at Durban, of finished petroleum products from imported crude oil have been announced. This, the first crude oil refinery for South Africa, will be erected at Wentworth, Durban, by the Standard-Vacuum Refinery Company of South Africa (Pty.), Ltd., at a cost of approximately £4,500,000. The refinery will be situated on a site of approximately 200 acres. It is expected that process designs and construction plans will be completed by the end of this year, that work will start early in 1952, and that the refinery will be finished late in 1953 or early in 1954.

The annual quantity of crude oil processed will be in excess of 125,000,000 Imperial gallons, giving a range of products from petrol to crude oil, petrol constituting the major yields.

The design of the refinery will embody a "combination unit," in which a fluid catalytic cracking plant will be directly linked with crude fractionating and thermal reforming facilities. Chemical treating equipment, storage tanks, workshops and administration building, a laboratory, a medical centre and other amenities will supplement the main processing unit. A pipe-line system, 4½ miles long, will connect the refinery with the existing ocean terminal at Island View, where tankers will discharge their crude oil cargoes.

Australian Engineering News

(From our Australian Correspondent)

Australian Steel Prices

A recent inquiry which has been conducted by the Commonwealth Tariff Board has revealed some extreme discrepancies in the prices which manufacturers here are paying in order to procure steel in a "starved" market. Although the inquiry relates officially only to the local and oversea production costs of certain household equipment, the situation disclosed is one of considerable interest to many United Kingdom exporters. The function of the Board is to determine (in each case brought before it) the appropriate duty to be placed on imports into Australia. Under Article 10 of the Ottawa Agreement the Board is bound to examine the relative costs "of economical and efficient" production, both here and abroad and all interested parties are entitled to submit evidence. One salient fact is that many manufacturers here are constrained to make use of a very high percentage of imported steel, in some cases 90 per cent. The great disparity in prices is shown by the fact that £110 per ton is being paid for steel from Japan, compared with £49 per ton from the United Kingdom, and about £28 per ton for the Australian product. Recently Mr. S. S. Ferguson, director of the Australian Association of British Manufacturers, was heard by the Tariff Board and is reported to have said, *inter alia*:

"For years the superstructure of Australian industry has been growing bloated and top-heavy relatively to the basic industries, which form its foundation, and the trend has recently gone a great deal further." "The fundamental trouble," he added, "seems to be that too large a proportion of the Australian labour force is engaged in steel-using industries and too small a proportion in the basic industries of coal and steel."

Extraction of Salt from Sea Water

The Broken Hill Proprietary Company, Ltd., which uses a considerable amount of salt in the various industrial processes which it controls, has made a very successful experiment in winning salt from sea water, at Whyalla, South Australia, where recently 3000 tons were extracted. If further tests are equally satisfactory, the activity is likely to be greatly expanded. The company's engineers were confronted with the problem of forming non-porous natural pans for the evaporation of the sea water. They experimented with the theory that by keeping the clay pan constantly covered with water some of the ingredients in the water would not disappear, but would make a coating over the base of the pan. It was found that in this way a layer of gypsum was formed on the bed. The pans now hold water, and salt to a depth of 6in was deposited in them.

Proposed Oil Distillation Plant at Geelong, Victoria

The general manager of the Shell Company of Australia (Mr. E. N. Avery) has announced that his company will build at Geelong, near Melbourne, the largest crude oil distillation plant yet erected in Australia, at a cost of about £5,000,000. It is expected that the plant, which will be built on a 250-acre site, will be completed in about two years and will be able to handle 282,000,000 gallons of raw products yearly, processing twice as much as the present largest refinery in the Commonwealth—that of the same company at Clyde, near Sydney, N.S.W. In the first instance the target is the processing of some 210,000,000 gallons annually to yield 136,000,000 gallons of petrol; 28,000,000 gallons of diesel fuel, and 38,000,000 gallons of fuel oil. Approximate yearly consumption of petrol in Australia is now 580,000,000 gallons. The original intention of the company was to build a bitumen and lubricant refinery at Geelong, but the world petrol situation caused that project to be altered. The plant will be able to take crude oil from British Borneo, which is practically a 100 per cent sterling source, thus reducing Australia's need for dollar credits. A storage capacity up to 56,000,000 gallons will be developed, and the Commissioners of the Geelong Harbour Trust have undertaken to build a wharf capable of berthing 18,000-ton tankers with full facilities.

N.S.W. Coal Output Problems

Statistics compiled by the Joint Coal Board of New South Wales and embodied in its annual report tabled recently in the State Legislative Assembly are not encouraging. State production for 1949 (10,736,000 tons) was 900,000 tons below the output for the preceding year.

Although popular belief is that strikes and industrial troubles are the primary cause of that falling off in output, the Board states that the present situation is the consequence very largely of the inability of the industry to keep pace with an ever-expanding demand. It adds that even had there been no loss of production because of strikes, output would still have fallen short of requirements by 1,000,000 tons, and that allegedly many colliery owners were either reluctant or unable to develop their properties fully. That condition was aggravated by the general shortage of manpower and equipment. The only feasible remedy, the Board states, is to modernise many mines, increase mechanisation and open up new workings—a policy calling for great capital outlay on development and installation of plant. Another serious aspect is that it is estimated that the commonwealth will need 16,500,000 tons of N.S.W. coal during the current year, and that the demand will rise to 18,000,000 tons for 1953. The present potential production of open-cut mines is assessed at some 2,000,000 tons yearly, but during the year 1949–50 output of open-cut mines was only 1,402,000 tons, because of a general strike and phenomenally wet weather.

LONDON TRANSPORT APPOINTMENTS.—London Transport announces the following appointments in the Department of the Chief Mechanical Engineer (Railways):—Mr. R. I. D. Arthurton becomes a principal executive assistant with control, in the development division, of all work in connection with contracts for rolling stock and associated equipments, as well as all internal and external inspection work of the department. Mr. Frank Dickson, chief draughtsman in the development division, becomes a principal executive assistant.

French Engineering News

(From our French Correspondent)

Electricité de France is to import Swiss current until March 31, 1960, within the limit of 35,000kW, for the period September 1st to March 31st each year. This is the result of a contract between Electricité de France and the Société Energie de l'Ouest Suisse.

* * *

The Société des Chantiers et Ateliers de Provence has just launched, at Port-de-Bouc, a banana vessel, the "Kiffa," with a capacity of 4120 cubic metres. A sister ship, the "Koba," will be launched during the summer. The "Kiffa" will be replaced on the slipway by the "Fort-Richelieu," a 6200 cubic metre banana ship.

A 7080-ton cargo vessel is to be constructed by the Ateliers et Chantiers de la Loire at its Nantes shipyard and a 7500-ton cargo vessel at its Saint-Nazaire shipyard.

* * *

An agreement has been signed between the Houilleres du Bassin de Lorraine, several steel companies in the East of France, and Gaz de France, which will permit the supply of gas from the eastern coking plants to Paris by a gas pipe-line. It is expected that the agreement will give rise to an increase in the carbonisation of Lorraine coal and an increased gas supply for the Paris region. Work on the pipe-line has been going ahead for some time but will not be completed for another two years, when it will supply Paris with 1,000,000 cubic metres of gas per day. The cost of the pipe-line will be about £6,000,000. It will involve the use of 34,000 tons of steel pipe covering a total length of 600km, and it is thought that it will be the most important high-pressure gas pipe-line in Europe.

* * *

A recent experiment in which a blast-furnace was fed with unselected and uncrushed ores over one year and functioned satisfactorily is described in the *Revue de Metallurgie*. The crushing plant was not ready in time and so it was decided the furnace should be fed with large blocks of ore. Explosion of the blocks, it was calculated, would increase the quantity of dust, coke consumption would rise and efficiency would vary. But as a 6·50m blast-furnace had never been given such a test it was decided to continue with the experiment.

After one year it has been reported that the blast-furnace functioned smoothly and there were no accidents. Pressure was regular and the pig quite satisfactory. The cost of production was reduced. Examination showed that the design of the furnace was such that it was not only able to take uncrushed ore but that many of the inconveniences found with crushed ores were eliminated. The hot air blast was evenly distributed and it was also found that when scrap was mixed in with the ores the blast-furnace worked well. The experiment will probably be continued and it is thought that it may result in modifications in design.

* * *

Some of the credits for the French Union, granted under the Marshall Plan, will be used for various engineering developments. The work to be undertaken will include development of the port at Konakry (300 million francs); irrigation in the Niger Valley (1400 million); modernisation of the West African railway network (380 million); roads in Equatorial Africa (600 million); roads in the Cameroons (400 million); and the development of water supplies in Brazzaville and Douala. In Algeria the programme includes two thermal power stations at Bone and Oran (500 million) and development of the power transmission grid (1600 million). Some 400 million francs will be spent on prospecting for oil and another 500 million on the development of water supplies at Oran and Mers-el-Kebir. A number of industrial developments are envisaged in Morocco, including modernisation of the mines at Djerada.

Industrial and Labour Notes

Britain's Steel Consumption

An interesting article in the current issue of the monthly statistical bulletin of the British Iron and Steel Federation gives notes on the concentration of steel consumption in this country. It is estimated that the number of firms in the United Kingdom which buy steel is about 150,000, most of them in very small quantities. In the engineering, shipbuilding and electrical equipment manufacturing industries some 50,000 firms are estimated to buy steel and the number of firms engaged in the manufacture of motor vehicles, aircraft, rolling stock, &c., is put at about 30,000. Steel users manufacturing other metal products, such as tools, cutlery, bolts and nuts, drop forgings, hollow-ware, &c., are estimated to number 15,000. To this number of steel users there may be added about half the 100,000 building and contracting firms in the country, which can be assumed to use finished steel, as well as a number of occasional users. Working on these round figures, the estimated number of 150,000 steel users is suggested as indicative of the right order of magnitude.

A table given with the article shows how heavily within these totals steel consumption is concentrated. The direct steel consumption of publicly owned organisations alone accounted for 11 per cent of the total steel usage in the fourth quarter of 1950. The first group of private firms in the table comprises those using over 2000 tons in the quarter and although it contained only 179 firms it accounted in aggregate for 31 per cent of the total consumption. The cumulative columns of the table show that 2000 firms are responsible for 70 per cent of the country's total steel usage.

The Iron and Steel Productivity Team

The Iron and Steel Productivity Team, representing the British heavy steelmaking industry, returned from the United States on July 5th after spending five and a half weeks visiting steel works in California, Texas and Colorado, as well as the traditional steelmaking areas in the East. A preliminary note issued on the team's work says that in view of the close technical links that already exist between the steel industries in the two countries, it was not expected that the visit would reveal striking new developments.

It found that high productivity in the American industry was primarily due to four factors—the size of the plant units, the purity of raw materials (resulting in a low metallurgical load), the tendency to drive units fast, and the use of high-grade fuel, including natural gas and fuel oil. The development of large units of production was assisted by a price and marketing system designed to avoid the interference to the flow of production arising from a high proportion of small orders, and by less exacting standards in finishing operations.

The normal manning of plant was generally the same in the two countries. The training of employees, other than those of supervisory grades, was less developed and incentive wage schemes were not used so extensively as in Britain. The framework of the American industry's structure in the union-management contract was "job evaluation," which the team studied with interest. The advantages both to management and labour in the United States of both process and maintenance workers being covered by the same union were apparent.

The Anglo-American Council on Productivity

The Chancellor of the Exchequer was questioned in Parliament last week as to the "principal benefits" which had resulted from the reports of the Anglo-American Council on Productivity. He was also asked whether he would produce a White Paper showing what had been done and what remained to be done.

In his reply, the Chancellor said that the reports had made available to a wide range of British industries thorough and well-balanced studies of American practice and methods of increasing productivity. Many of the recommendations had been put into effect in the industries concerned, and others were being gradually implemented. In addition, the programmes of conferences on the subjects of the reports had proved valuable in stimulating discussion and action on productivity problems.

The responsibility for sending productivity teams to the U.S.A. and for making use of their reports, the Chancellor added, rested with the Anglo-American Council on Productivity, which was an independent body representing both sides of industry. In view of the extensive publicity already given to the Council's activities, and to the recommendations of the teams, he did not think it was necessary to publish a White Paper.

Carbon and Graphite in the United States

It has been announced by the boards of Powell Duffryn Carbon Products, Ltd., and of Great Lakes Carbon Corporation of New York, that an agreement has been entered into under which a jointly owned company, British-American Carbon Corporation, has been formed in the United States to manufacture and sell carbon and graphite, and a wide range of carbon and graphite products used principally by the chemical, metallurgical and other processing industries.

The new company will be the sole producer in the United States of carbon and graphite manufactured directly from coal by the Powell Duffryn "Delanium" process, and its products will include the specialities developed by Powell Duffryn Carbon Products, Ltd., in this country.

Mr. William J. Crawford, formerly of Great Lakes Carbon Corporation, has been elected president of the new company, which will have offices at 18, East 48th Street, New York City, New York, U.S.A.

Distribution of Tungsten and Molybdenum

The International Materials Conference announced on July 6th that the member countries participating in the Tungsten-Molybdenum Committee had accepted the committee's conclusion that an interim plan of distribution of tungsten and molybdenum for the third calendar quarter of 1951 should be put into operation at once. These allocations, it is stated, will be in the nature of a stop-gap, and should not be regarded as establishing a permanent pattern for future allocations. The plan includes an agreement on maximum and minimum prices for tungsten, to apply during the stated period.

The Committee's recommendations, which the participating governments have now accepted, deal primarily with the distribution of ores and concentrates of the two metals, which in both cases are extremely scarce. The distribution of primary products has been made the subject of a further recommendation by the Committee to the governments. From July 1 to September 30, 1951, the United Kingdom will receive 695 metric tons of tungsten ores and concentrates and 515 metric tons of molybdenum, all of which will be imported.

Overseas Trade in June

The value of United Kingdom exports in June totalled £200 million and was 13 per cent below the figures for April and May. April exports included consignments, which had been held up as a result of shipping difficulties in earlier months, and the May total included abnormally heavy exports of ships. A fall in exports of ships accounted for £5 million of the reduction between May and June and the fact that June contained one less working day might have accounted for a reduction of about 4 per cent but, even if these two factors are allowed for, the rate of export in June was some 7–8 per cent below the May level. Despite the lower June figure, the value of exports in the second quarter was still 14 per cent above that of the first quarter of 1951 and 22 per cent above the average for the year 1950.

The value of imports showed a further increase of £357·5 million and brought the second quarter total to £1008·3 million, 19 per cent above the first quarter total. Imports in the first half year were 43 per cent above the 1950 average.

Re-exports amounted to £8·6 million in June and £63·9 million in the first six months of the year: total exports, including re-exports, were valued at £1304·2 million (f.o.b.) and the excess of imports (valued c.i.f.) over total exports (valued f.o.b.) for the half year was £552·2 million, compared with an excess of £220 million in the first half of 1950. For the whole of 1950 the excess was £347·9 million. In June alone the excess of imports over exports on this basis was £148·9 million.

Coal Supplies Next Winter

The annual report of the Industrial Coal Consumers' Council to the Minister of Fuel states that unless the improved trend in output resulting from Saturday or overtime working and from rising manpower in the mines continues, there is great danger that the country will be faced with another fuel emergency next winter. It urges that if it should be necessary to import coal again this year, it should be done during the summer before a crisis arises. At a press conference, Mr. T. Coxon, on behalf of the Council, said that there were signs that the gap between rates of production and consumption of coal were widening and that alarm had been expressed at the rate of stockpiling. Experiences of the past winter, coupled with the knowledge that opencast coal production in Britain could not have a long lease of life, confirmed the opinion that for some years to come there would not be enough coal to meet growing demands and essential exports. Concern is expressed in the report at the further use of flat-rate increases, applied without discrimination to all qualities of coal, to produce the larger revenue required by the National Coal Board. If coal cost could be stabilised, or, better still, reduced by greater productivity, it would be an important gain. By such a step the whole country, including the mineworkers themselves, would benefit.

Replying to a question in the House of Commons on Monday last, the Minister of Fuel said that on July 7th, the latest date for which figures are available, coal stocks held by engineering and other industrial concerns amounted to 3·505 million tons and household coal stocks to 604,000 tons. The industrial coal stocks were 479,000 tons more and the household coal 225,000 tons fewer than at the corresponding date last year.

Zinc Supplies

A notice issued by the Ministry of Materials points out that misunderstanding has arisen over a statement about zinc made by the Lord Privy Seal in the House of Commons on June 27th. The notice says that there was nothing in the Minister's statement to suggest that because other processes should be introduced so as to save zinc used in galvanising, there will be less need for zinc to be produced in the United Kingdom, and imported from the Commonwealth and other sources.

The Lord Privy Seal considers it important that the use of alternative materials should be encouraged as far as practicable, and that the research into ways and means of saving zinc in galvanising and for other purposes should be accelerated. If this could be done it would then be possible to release more zinc for processes in which no serviceable substitutes are likely to be made available.

Notes and Memoranda

Rail and Road

RECONSTRUCTION OF DERBY MIDLAND STATION.—The present roof of Derby Midland station, which is still largely the original structure erected by Robert Stephenson in 1839, and was badly damaged by enemy action during the war, is to be replaced by one of prestressed precast concrete awning design. The provision of new waiting rooms, toilets and refreshment rooms on the island platforms, a new footbridge giving access to all platforms from each side, and an additional footbridge on No. 1 platform is also envisaged, and the station will be lit by electricity instead of gas as at present. A new signalbox is to be constructed in place of the existing one, and the present signals replaced by modern equipment. British Railways (London Midland Region) hope to begin the work in the late autumn. The cost will be about £200,000.

Air and Water

"AVRO DELTA 707A."—At Boscombe Down, Wiltshire, another "delta" wing aircraft has recently made its first flight. This aircraft is designated the "Avro Delta 707A," being made by A. V. Roe and Co., Ltd., and is the third machine made by this company to be fitted with a triangular wing form. The "707A" is fitted with a Rolls-Royce "Derwent" jet turbine, and has a span of 34ft 2in, an overall length of 42ft 9in, and a height of 11ft 7in. This machine has been developed from the "707B" aircraft which has been flying since September of last year, and itself was a longer and modified version of the original "707" machine which crashed within a few weeks of its first flight in 1949. There are now four aircraft investigating the properties of the "delta" wing configuration in this country.

Miscellanea

TUNGSTEN.—The Ministry of Materials announces that it will become the sole importer and distributor of tungsten ores and concentrates as from July 30th. Shipments licensed for import and already sold to consumers will not be affected by these new arrangements, and a further announcement, describing the arrangements in more detail, will be made a few days before they come into effect.

BRITISH RAILWAYS' SPECIAL WAGONS FOR CHEMICALS.—The Railway Executive states that British Railways will build thirty-two covered hopper wagons of 25-ton capacity for the bulk conveyance of "catalyst" and sodium tripolysulphate; catalyst is used in converting crude oil into a wide range of petroleum products, and sodium tripolysulphate in the manufacture of synthetic soaps. All the wagons will be constructed in the British Railways' works at Derby.

MARINE RADAR OPERATORS' SCHOOL AT GREENOCK.—The radar operators' school which has been established at the James Watt Memorial School, Greenock, was formally declared "open" last month (June) by Captain R. C. Lewis, D.S.O., O.B.E., R.N., at a ceremony attended by representatives of several shipping lines and of the Ministry of Transport. Standard B.T.H. 3cm marine radar (type "RMS.1C") is installed at this commercial radar school, which is the first of its kind in Scotland. The siting of the installation is such that an excellent plan picture of the Clyde within a radius of 25 miles is obtained. The instruction given will include training in marine radar maintenance to the approved standards set by the Ministry of Transport. For ease of instruction, the standard radar cabin has been omitted, the various units being mounted in a class room.

CARRIAGE AND WAGON MANUFACTURE.—Last week a large company of guests visited the Saltley and the Midland works of the Metropolitan-Cammell Carriage and Wagon Company, Ltd., at the invitation of the directors, to inspect the production methods developed for rail vehicles and see examples of the carriage and wagon stock now being manufactured for railways at home and overseas. This company has long specialised in the fabrication of all-steel stock and units and the visitors noted with particular interest the comprehensive system of welding jigs, fixtures and manipulators which had been introduced in the works to facilitate production. Of particular note was the lightweight all-steel multiple-unit electric rolling stock being built for use on the suburban routes of the Great Indian Peninsula Railway and the Bombay, Baroda and Central India Railway. The design of these coaches was based on stress calculations which were checked by a newly developed test rig laid down in the company's works. In this test rig buffing loads up to 150 tons were applied and the equivalent of various vertical passenger loads imparted on the floor of a vehicle. During testing a full record of stress values at all important points was taken by means of electrical resistance strain gauges. By this development of stress calculation in designing the structural members and the introduction of suitable materials a saving of some 26 per cent has been made in the weight compared with the conventional motor coaches in service. There were also shown in course of construction some of the ninety light alloy coaches designed by the company for the London Transport Executive, and which are some 37 per cent lighter than the standard all-steel coaches in service.

YALLOURN POWER STATION.—The power development programme of the Victoria State Electricity Commission provides for extension of the power station at Yallourn with complementary exploitation of the nearby brown coal deposits at Morwell. The extensions at Yallourn will be in two stages: the first (for completion in 1953) involves two 50MW turbo-alternators, one 60MW back-pressure set, and the associated boiler plant; the second stage (for completion in 1956) will consist of two more 60MW sets and boiler plant.

THE MANUFACTURE OF ALLIS-CHALMERS LOW-HEAD SCREENS IN ENGLAND.—It is announced that the sale and manufacture of Allis-Chalmers low-head screens in England has been inaugurated by the company's London office at 728, Salisbury House, London Wall. The screens will be built to Allis-Chalmers designs by MacKay Industrial Equipment, Ltd., of Feltham, Middlesex. The screen, which is suitable for dry or wet screening, rinsing or dewatering, consists of two units—a screen body and a vibrating mechanism. The screen body, comprising side plates, frame and mechanism support, is made of high-tensile alloy steel. To save headroom the single or multiple screens are horizontally mounted. The motor-driven vibrating mechanism is continuously splash lubricated by the passage of counterweights through oil contained in a reservoir in the lower portion of the housing.

AIR TRAFFIC STATISTICS, 1950–51.—Provisional operating and traffic statistics for the financial year ended March, 1951, show that the United Kingdom Airways Corporations flew almost one-third more traffic than in the previous year. They flew 835 million passenger-miles, an increase of 32 per cent. Freight and mail ton-miles flown were 24 million and 13 million respectively, constituting increases of 30 per cent and 18 per cent over 1949–50. The passenger load factor was 57 per cent compared with 62 per cent in 1949–50, and the overall revenue load factor 59 per cent, compared with 57 per cent. British Overseas Airways Corporation increased its total traffic by 31 per cent to 84 million revenue load ton-miles, carrying 196,000 passengers for a total of 569 million passenger-miles, at a passenger load factor of 56 per cent. British European Airways traffic rose by 25 per cent to 28 million revenue load ton-miles, compared with 22¼ million in 1949–50, at a load factor of 58 per cent in 1950–51 compared with 61 per cent in the previous year. The figures for passenger traffic were 940,000 passengers carried and 266 million passenger-miles flown.

NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD MOBILE SHOWROOM.—The North of Scotland Hydro-Electric Board has put into service a mobile showroom, designed for use in the isolated parts of its area where electricity is being supplied for the first time. It will be driven to isolated farms and crofting townships and connected by cable to the overhead lines. For travelling along narrow roads the van had to be restricted in size by providing telescopic sides, which expand to form bays in which equipment can be displayed. Internal wiring enables the equipment, which normally will include an electric cooker, washing machine, vacuum cleaners, fires, irons, kettles, and lights, to be shown in operation. There is a 50-gallon cold water tank and a 25-gallon hot water tank heated by electricity. A 20-gallon tank is provided for waste water and washing and ironing demonstrations can be carried out. There is accommodation for twelve people in the van, but there is provision for the erection of an awning so that larger audiences can see the demonstrations. The mobile showroom, which is mounted on an extended 2-ton Fordson "Thames" chassis, made its first public appearance at the Coupar-Angus Farmers' Show in the county of Angus on July 14th, and after visiting agricultural shows in Perthshire, Kinross, Moray, Banff, and Aberdeenshire, it will be based on the northern counties.

INSTITUTION OF ELECTRICAL ENGINEERS.—A recent announcement by the Institution of Electrical Engineers gives the constitution of the council and section committees for the session 1951–52. The President will be Sir John Hacking, Deputy Chairman (operations) of the British Electricity Authority. The two new vacancies for Vice-Presidents will be filled by Colonel B. H. Leeson and Dr. W. G. Radley. The Honorary Treasurer will be Mr. H. Nimmo. As the result of a ballot eight new ordinary members of council were elected as follows:—Mr. J. O. Knowles, Mr. B. L. Metcalf, Dr. J. L. Miller, Mr. R. W. Mountain, Mr. D. P. Sayers, Professor F. C. Williams (members), Mr. J. F. Bird (associate member), and Mr. S. L. M. Barlow (associate). The Chairmen of the specialised sections will be as follows:—Measurements section, Mr. F. J. Lane; radio section, Dr. D. C. Epsley; supply section, Mr. R. Davis; utilisation section, Mr. A. H. Young.

JUTE SACKS AND FIRE DANGER.—Spontaneous combustion is often alleged to be the cause of fires in stored products, and the Fire Research Organisation has now shown that the jute sacks in which materials are stored may themselves be a fire hazard. The small hairs of the jute sacks enable flames to spread rapidly without leaving any trace of scorching, and fires started by, say, a cigarette end may be wrongly attributed to spontaneous heating. Fires which have been caused, at first sight, by spontaneous ignition have been studied in co-operation with the Home Office and the fire brigades. A number of such fires occurring in materials stored in jute bags appeared to have started at one or several points inside the stack. Many of these fires, however, bore a strong resemblance to other fires in stacks which were known to have been started from outside. In these fires the flames spread rapidly for a few moments via the bag hairs, over the stack and through the spaces between the bags. When the flame met frayed fabric inside, a smouldering fire was sometimes started, without anyone realising it. Such a fire started by, for example, a smouldering cigarette end, could cause a flame to run into the stack and start a fire inside which may be seen only hours later and would later be put down to spontaneous combustion.

Personal and Business

POWER JETS (RESEARCH AND DEVELOPMENT), Ltd., has appointed G. C. R. Mathieson to be Senior Lecturer at the School of Gas Turbine Technology, Farnborough, Hampshire.

GEORGE KENT, Ltd., announces that Mr. L. A. C. Bartlett and Mr. W. A. H. May, have been appointed to the board of the company. Mr. Bartlett has been with the company for twenty-five years, and several months ago he was made commercial manager. Mr. May, who is a great-grandson of the founder of the firm, returned to the firm from the Forces in 1946 and is now administration manager.

SANTON, Ltd., of Newport, Mon, has just moved into a large new factory at Somerton. Mr. G. G. Burton has been appointed works manager of the new factory, and Mr. R. J. Trevelyan becomes manager of the firm's other factory known as County Works. Mr. J. C. Sanders, who, since 1942, has held the dual position of works director and works manager, will now devote the whole of his time to his responsibilities as works director of the two factories.

LANCASHIRE DYNAMO AND CRYPTO (MFG.), Ltd., announces that Mr. A. J. C. MacLeod, sales manager for the Willesden Works products of the company, has now been appointed export manager and will operate from the company's London office at 94, Petty France, London, S.W.1. The company has also appointed Mr. V. W. Press London area sales manager. Mr. Press, who joined the company in 1934, has been senior sales engineer in the Kent/Hampshire area, and has been particularly identified with variable speed drive problems and electrification in gas works.

LONDON TRANSPORT announces that following the appointment of Mr. E. C. Ottaway as Chief Supplies Officer, Mr. J. W. Wicks has been appointed works manager (buses and coaches); Mr. J. Schofield, M.C., has been appointed works manager (trams and trolleybuses), responsible for the overhaul work on trams and trolleybuses at both the Charlton and Fulwell works; Mr. N. H. Charles has been appointed planning and methods engineer (road services—works), and Mr. W. D. D. Brewer has been appointed an officer of the Executive with the title of progress and materials superintendent (buses and coaches).

British Patent Specifications

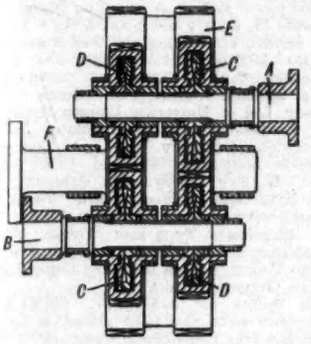
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application: the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

POWER TRANSMISSION

654,652. June 18, 1947.—Power Transmission Mechanisms, Thomas Hindmarch, of Lindo Lodge, Stanley Avenue, Chesham, Buckinghamshire.

The object of the invention is to provide a power transmission without any idler wheels, so that the transmission will be suitable where light weight and space restrictions are important. The drawing shows a form of drive adapted for two prime movers, of which the respective input shafts are shown at *A* and *B*. Each input shaft carries two pressure fluid operated clutches *C* and *D*, the outer



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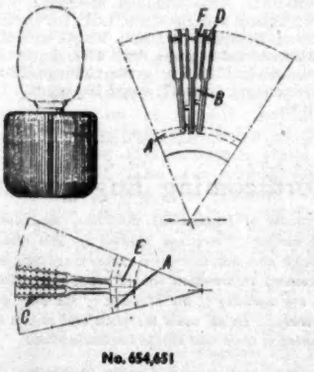
driven members of the clutches *C* meshing with the gear wheel *E* on the output shaft *F*, while the outer driven members of the clutches *D* are not in mesh with the gear wheel but mesh with the outer driven members of the clutches *C*. The arrangement is such that the output shaft *F* will be driven in one direction of rotation when the clutches *C* are engaged and in the reverse direction when the clutches *D* are engaged. The neutral position in the transmission is given when all clutches are disengaged. Modifications for engines running in opposite directions and for four engines driving on a common output shaft are described in the specification.—*June* 27, 1951.

HEAT EXCHANGERS

654,651. May 23, 1947.—Cylindrical Heat-Exchangers, Society Anonyme Des Usines Chausson, of 35, rue Malakoff, Asnières, Seine, France.

This invention relates to cylindrical heat-exchangers comprising a sleeve with a group of radial fins, which are used for dissipating the heat produced by the anode of thermionic valves for



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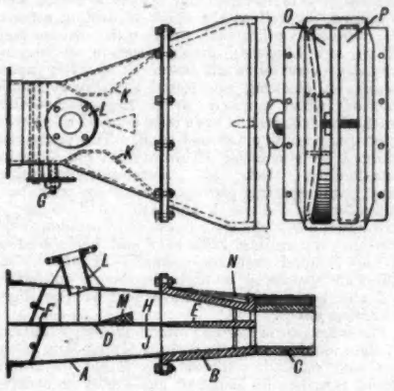
radio or high-frequency heating or heat-engines. The upper left-hand view shows a cylindrical heat-exchanger (for cooling a transmitter valve), comprising a cylindrical group of radial fins held on a central sleeve. As shown in the right-hand upper view, a sleeve *A* is provided with slots in which the forked fin bases are engaged. The fins are made of metal sheet, which is cut out and folded; the two portions in the zone near the sleeve are pressed together so as to form, between the adjacent fins, passages *B* of substantial cross-section. The outer portions of the folded sheet are bent apart to form a fork, to provide further passages between them, so that in the outer zone the number of passages is doubled. To retain the spacing between the fins and between the forked arms, tongues *C* and *D* are cut out and bent in the metal sheet, forming the fins, as shown in the drawing. The lower sectional drawing shows a modification in which use is made of forked fins with arms made by drawing or other like processes. A base *E* having two radial sides is formed on the fins. The shape of these fins is such as to produce air passages, the cross-sections of which are substantially uniform. Secondary fins *F* may be formed on the arms of the forked fins and on the bodies so as to increase the heat exchange.—*June* 27, 1951.

FURNACES

654,641. March 17, 1947.—Burners for Pulverised Fuel, The Blaw-Knox Company, of 307, Fifth Avenue, Pittsburgh, Pennsylvania, U.S.A.

The burner as shown in the drawings comprises an entrance section *A*, a distributing section *B* and a terminal mouth or mixing section *C*, which have generally rectangular cross sections. The entrance section can conveniently be fabricated from sheet metal, the distributing section may be a casting and the mixing section is preferably a hollow tile of refractory material. The sides of the entrance section and distributing section diverge, while their tops and bottoms converge as shown. The mixing section is of substantially uniform sectional dimensions throughout and conforms in shape to the forward end of the distributing section. A partition or horizontal wall *D* is disposed substantially equidistant from the top and bottom of the entrance section. A similar wall or partition *E* is provided in the distributing section. Ribs extend from the wall to the top and bottom of the distributing section. The walls divide the entrance and distributing section into upper and lower passages *H* and *J*. Dampers *F* are located in the upper and lower passages, respectively, being mounted on shafts extending through opposite side walls of the section adjacent its entrance end. The shafts are provided with quadrants *G* whereby the dampers may be manually adjusted to control the division of air from the blower between the upper and lower passages. The side walls of the passage *H* are constricted in the entrance section to provide a Venturi throat. This is done by filler plates *K* extending between the wall and the top of the entrance section. A neck *L* depending from the lower end of the fuel concentrator communicates with the upper passage adjacent the Venturi throat afforded by the walls *K*. This arrangement induces fuel through the neck into the air stream. A pyramidal baffle *M*, located on the partition, has the effect of deflecting the entering air and fuel toward the sides of the entrance and distributing sections of the burner. The top of the distributing section *B* is downwardly bowed transversely as indicated at *N*. As shown the outlet of the upper passage *O* has a width several times its depth and has a depth at the centre which is considerably less than at the sides. This has the effect of laterally spreading the stream of air and fuel flowing therefrom. The outlet *P* of the lower passage also has a width several times its depth and accordingly discharges a shallow flat stream or jet of secondary air below the similarly shaped stream of mixed fuel and air emerging from the outlet *O*. The mixing section *C*, where ignition of the fuel occurs, is simply a hollow refractory tile, whose sectional shape corresponds to that of the distributing section at its discharge end. The burner delivers to the combustion space a relatively shallow flat layer or blanket of air rich in pulverised fuel. Below the fuel-air layer a wide, shallow layer or blanket of secondary air is introduced. The secondary air tends to rise and the fuel to fall after reaching the ignition point, which affords intimate mixture and complete combustion. The flame projecting from the burner is thus shorter and smaller than the flame characteristic of pulverised coal burners known heretofore, and the amount of excess air needed to insure complete combustion is reduced.—*June* 27, 1951.



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METALLURGY

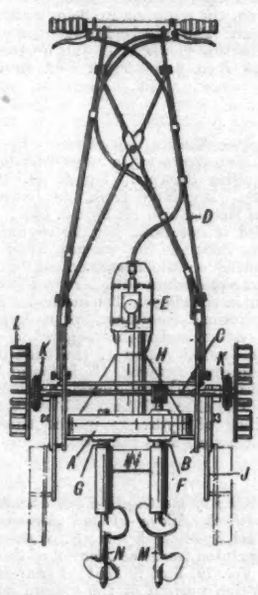
654,911. October 30, 1948.—The Production of Cast Irons, The British Cast Iron Research Association, of Alvechurch, near Birmingham, and Henton Morrogh, of 9, Headingley Road, Handsworth, Birmingham.

This invention relates more particularly to methods for the introduction of magnesium into cast iron. It provides a new and practicable method of introducing magnesium into molten iron by the use of magnesia or a magnesia-generating compound. In the absence of elementary silicon, temperatures above 1650 deg. Cent. are necessary; but if the magnesia is associated with silicon, reduction to magnesium metal takes place at above 1100 deg. Cent. and proceeds more readily at 1250 deg. Cent. or higher. The magnesia, with or without silicon, may be applied as a refractory lining to the walls of the furnace or the runs or the ladle, always bearing in mind that unless the magnesia is associated with a due proportion of silicon temperatures above 1650 deg. Cent. must be used. The magnesia-silicon mixture is briquetted as described in the specification and held under the surface of the molten iron in the ladle, at temperatures above 1100 deg. Cent. until sufficient has dissolved. Magnesium is a well-known desulphurising agent and the invention provides a convenient method of reducing the sulphur content of iron during casting. When magnesium has been used in quantity more than sufficient to reduce the sulphur content of the cast iron to below 0·02 per cent, magnesium metal dissolves in the iron and an alloy containing as much as 1 per cent of magnesium can be produced. —*July* 4, 1951.

AGRICULTURAL ENGINEERING

654,280. February 10, 1948.—Cultivating and Tilling Machines, Wharton and Wilcocks, Ltd., formerly known as Wharton and Olding, Ltd., and William Wharton, both of Junction of Great North Road and Barnet By-Pass Road, Hatfield, Hertfordshire.

The invention relates to cultivating and tilling machines of the manually controlled sort embodying tynes rotatable by a motor which can be pushed into the earth. The driving mechanism is designed



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for imparting a continuous rotary motion to the supporting wheels and comprises a gearbox *A* supported in a frame constituted by a pair of side plates *B* spaced apart by a rod and also by a shaft *C*, which is rotatably mounted in the plates. A pair of bars *D* pivotally mounted on the plates are connected at their upper ends by a handle bar. A motor *E* is mounted on the gearbox and its spindle has on its lower end a gear wheel arranged to mesh with a gear wheel adjacent the upper end of the spindle *F*, and this wheel, in turn, meshes

with a further gear wheel on the upper end of the spindle *G*. The spindle *F* passes through the top of the gearbox and is provided on its extreme upper end with a worm arranged to act with a worm wheel *H* on the shaft, so that when the spindle *F* rotates it also causes the shaft *C* to rotate. The ends of the shaft pass through bearings in the plates, and on each of the extreme outer ends of the shaft is mounted a bell-crank lever *J*, on the end of the short arm of which is mounted a sprocket wheel. Adjacent the outer ends of the shaft *C* are sprocket wheels *K*, the endless sprocket chains being supported on the sprocket wheels at each end so that a continuous drive is provided between the spindle *F* and the sprocket wheels, which are arranged to rotate the wheels *L* of the machine mounted on the short arms of the bell-crank levers. The side plates are furnished with notches for the angular adjustment of the bars *D* relatively to the motor gear casing *A* and the tynes *M* and *N* as illustrated. The tynes rotate in opposite directions, and in the working position are at an angle of about 45 deg. in the earth to be broken up. In operation the motor *E* imparts a continuous rotative movement to the spindles *F* and *G* and through the worm and worm wheel and sprocket drives, to the wheels *L*. In certain circumstances, the wheels may alternatively be fitted to the carriage without any propulsive drive from the motor, and may be dismounted and remounted on spindles on the ends of the bell-crank levers, as indicated by the broken lines.—*June* 13, 1951.

Technical Reports

The Constitution of Titanium-Rich Alloys of Iron and Titanium. By H. W. Worner, M.Sc. Reprinted from the *Journal* of the Institute of Metals, Vol. 79, Part 3, 1951. Synopsis.—Metallographic and X-ray methods have been employed to establish the general outline of the constitutional diagram for the titanium-rich portion of the titanium-iron system. The results of the investigation indicate that addition of iron causes a depression of both the freezing point and the $\alpha \rightleftarrows \beta$ transformation temperature of titanium. From the melting point of titanium, the liquidus and solidus fall steeply to a eutectic horizontal at 1060 deg. Cent., the eutectic composition being at 29 at. per cent iron. This eutectic consists of an intermetallic phase (FeTi), possessing a body-centred cubic structure, and a solid solution of iron in the high-temperature (β) form of titanium. The maximum iron content of the β-solid solution is approximately 22 at. per cent at the eutectic temperature. At lower temperatures the β-solid solution field tapers to a eutectoid point at 15·5 at. per cent iron, the temperature being approximately 600 deg. Cent. The eutectoid transformation, which is very sluggish, yields FeTi and α-titanium containing less than 0·8 at. per cent iron in solid solution.

The Application of Hydrogen Equilibrium-Pressure Measurements to the Investigation of Titanium Alloy Systems. By A. D. McQuillan, Ph.D., B.Sc. Reprinted from the *Journal* of the Institute of Metals, Vol. 79, Part 2, 1951. Synopsis.—A method is described for the investigation of equilibrium relations in certain alloy systems, which depends on the measurement of hydrogen pressures in equilibrium with a very dilute solution of hydrogen in the alloys. The method is illustrated by a theoretical treatment of a hypothetical, simplified system, and is then applied to a series of alloys in a limited region of the titanium-copper and titanium-iron systems. It is found that both copper and iron depress the $\alpha \rightleftarrows \beta$ transformation in titanium. The effect of these addition elements on the solubility of hydrogen in the titanium-rich β solid solution has been examined.

The Stability of the Co_2Al_9-Type Structure in the Aluminium-Rich Alloys of the Aluminium-Iron-Cobalt-Nickel System. By M. B. Waldron, B.Sc., Ph.D. Reprinted from the *Journal* of the Institute of Metals, Vol. 79, Part 2, 1951. Synopsis.—In the aluminium-rich portion of the system aluminium-iron-cobalt-nickel there exists a quaternary phase $(Fe,Co,Ni)_2Al_9$, whose range of homogeneity includes the terminal compositions Co_2Al_9 and $FeNiAl_9$; electron : atom (e/a) ratios of 2·12 and 2·16 respectively, can be assigned to these compositions, assuming that cobalt, iron and nickel may accept respectively 1·71, 2·66 and 0·61 electrons per atom from the structure as a whole. The iron-rich boundary of the phase, which corresponds to the lower limit of the e/a ratio, starts as a straight line of constant e/a ratio 2·07 from the Co_2Al_9 region, but changes direction sharply, when half the cobalt atoms have been replaced by iron and nickel atoms, and approaches linearly a value giving an e/a ratio of 2·14.

The lower limiting e/a ratio of a phase is determined by the point at which the depletion of electrons reduces the binding energy of the structure relatively to that of an alternative phase. Thus, compositions in the region of Co_2Al_9 appear to be more stable than those in the region of $FeNiAl_9$, since Co_2Al_9 permits solution of iron until the e/a ratio has been reduced from 2·12 to 2·07, compared with a reduction from 2·16 to 2·14 in the region of $FeNiAl_9$. Melting points are further indices of stability: Co_2Al_9 melts at 943 deg. Cent. and forms a eutectic with $FeAl_3$ and the aluminium-rich solid solution; $FeNiAl_9$ is formed peritectically from $FeAl_3$ at 809 deg. Cent.

An experimental technique has been devised which makes possible the determination of the composition of the quaternary phase at the point where the eutectic relationship with $FeAl_3$ changes to the peritectic reaction. This is found to occur at the phase composition associated with the change in direction of the phase boundary and is an interesting verification of the dependence of the stability of this type of intermetallic compound on the e/a ratio. The experimental technique may prove useful in other systems in which it is necessary to investigate a peritectic reaction.

The Effect of Mould Material and Alloying Elements on Metal/Mould Reaction in Copper-Base Alloys. By N. B. Rutherford, B.Sc. Reprinted from the *Journal* of the Institute of Metals, Vol. 79, Part 4, 1951. Synopsis.—When a metal is cast in a sand or other mould in which a steam atmosphere is generated, it reacts with the steam and may absorb hydrogen during the reaction. The term "metal/mould reaction" is used to describe this effect.

The results are described of experiments to determine the influence of different mould materials on the mould reaction in phosphor-bronze containing 10 per cent tin and 0·5 per cent phosphorus. The effects of variations in the moisture content and permeability of natural and synthetic sands were examined, as well as the effect of adding mineral and vegetable oil, cereal, resin and cellulose-derivative core binders; mould reaction of varying intensity occurred in all cases. A sprayed mould coating of blacking was found to increase mould reaction when applied to a high-permeability synthetic sand, but to have only a small effect with a low-permeability natural sand. The protection afforded by a coating of aluminium paint varied considerably, but an aluminium-magnesium alloy paint coating prevented reaction with both naturally bonded sand and various core sands. Individual additions were made of bituminous coal, sulphur, ammonium bifluoride and boric acid to a clay-bonded synthetic sand; of these, the bifluoride produced a high degree of inhibition and the boric acid may have had a very slight inhibiting effect.

The influence of various minor alloying additions on the mould reaction in certain copper-base alloys was also studied. Silicon was found to inhibit mould reaction in lead-free gun-metal containing 0·1 per cent phosphorus, as it does in phosphor-bronze. Leaded gun-metals containing 0·03 per cent silicon or more yielded castings with poor surfaces and with increased porosity which is attributed to the incidence of mould reaction. In phosphor-bronze, mould reaction was inhibited by additions of 0·1 per cent aluminium, 0·5 per cent chromium, 0·1 per cent vanadium, 0·1 per cent boron, and possibly by small amounts (0·01 per cent) of calcium. Running practice would probably need to be modified if additions of aluminium or chromium were adopted on a production scale, and perhaps with vanadium and boron also, because of the formation of tenacious oxide skins. Mould reaction in phosphor-bronze was intensified by the addition of 0·5 per cent iron or manganese, or 0·2 per cent magnesium, while additions of 0·5 per cent nickel, 0·1 per cent beryllium, or small amounts of barium or sodium had no effect. A number of theoretical considerations are discussed in this report.

Contracts

THE BURNTISLAND SHIPBUILDING COMPANY, Ltd., has contracted to build for Saguenay Terminals, Ltd., associates of the Aluminium Company of Canada, a 7850-ton deadweight bauxite ore carrier propelled by triple-expansion engines of 2000 h.p.

DURING June the British Electricity Authority placed contracts for equipment for power stations, transforming stations and transmission lines, amounting in the aggregate to £8,496,648. The principal contracts, including the erection of a 275kV double-circuit line between Scotland and Yorkshire and several bulk orders for transformers are :—Acton Lane "B" power station, London, framework for turbine house, switch house, workshop and stores (Sir Robert McAlpine and Sons, Ltd.); Brunswick Wharf power station, London, circulating water pipework (Aiton and Co., Ltd.) and ash and dust-handling plant (Babcock and Wilcox, Ltd.); Hackney power station, structural steelwork (Horseley Bridge and Thos. Piggott, Ltd.); Willesden power station, 33kV switchgear (A. Reyrolle and Co., Ltd.); Rye House power station, Herts, cables and accessories (British Insulated Callender's Cables, Ltd.); Meaford "B" power station, Staffs, coal-handling plant (Babcock and Wilcox, Ltd.) and 132kV, 2500MVA switchgear (General Electric Company, Ltd.); Uskmouth power station, Newport, foundations, tunnels and sundry works for coal-handling plant (John Morgan (Builders), Ltd.); Connah's Quay power station, Chester, generator and station transformers (C. A. Parsons and Co., Ltd.); Stella South power station, Blaydon-on-Tyne, site clearance, access roads, construction of sidings and offices, diversion of stream and sewers and other preliminary works (Sir Robert McAlpine and Sons (Newcastle on Tyne), Ltd.); Roosecote power station, Barrow, coal-handling plant (Robert Dempster and Sons, Ltd.); Huncoat power station, Accrington, drainage, roads and paths (J. Jarvis and Sons, Ltd.); Fleetwood power station, condensing and feed heating plants for two 30,000kW turbo-generators (Vickers-Armstrongs, Ltd.); Stourport power station, 132kV, 2500MVA switchgear (General Electric Company, Ltd.); Hawarden-Bangor, North Wales, 132kV overhead line (British Insulated Callender's Construction Company, Ltd.); Bonnybridge-Devonside, South-East Scotland, 132kV overhead line (J. L. Eve Construction Company, Ltd.); Clydes Mill, Glasgow-West Melton, Yorks, 275kV double-circuit overhead line from Clydes Mill to Stella, Blaydon-on-Tyne and Thirsk, Yorks, to West Melton (Balfour, Beatty and Co., Ltd.); and Stella to Thirsk (British Insulated Callender's Construction Company, Ltd.).

Bulk orders for 275/132kV, 120MVA auto-transformers have also been placed as follows:—British Electric Transformer Company, Ltd., four (Elstree); British Thomson-Houston Company, Ltd., three (Staythorpe, Notts, one, and West Melton, Yorks, two); English Electric Company, Ltd., two (Drakelow, Burton-on-Trent); Ferranti Ltd., two (Ferrybridge, Yorks); Metropolitan-Vickers Electrical Company, Ltd., four (Carrington Manchester); and C. A. Parsons and Co., Ltd., two (Stella, Blaydon-on-Tyne).

Launches and Trial Trips

HEWITT, motor tug; built by Henry Robb, Ltd., for the Ribble Navigation and Preston Docks Boards; length overall 92ft, breadth moulded 23ft, depth moulded 11ft 6in, mean draught 9ft; twin two-cycle, six-cylinder Crossley diesel engines, total b.h.p. 800 at 300 r.p.m. Trial June.

CERES, motor tanker; built by Furness Shipbuilding Company, Ltd., for Rederiaktiebolaget Ceres of Stockholm; length overall 523ft, breadth moulded 67ft 6in, depth moulded 36ft 5in, deadweight 16,300 tons; Doxford reversible single-acting, two-cycle oil engine, five cylinders, 670mm diameter by 2320mm combined stroke, 5500 b.h.p. at 114 r.p.m. Launch, July 18th.

NORMANNIA, cross-Channel steamer; built by William Denny and Brothers, Ltd., for the Railway Executive, Southern Region; length overall 312ft, breadth moulded at main deck 48ft, depth moulded to main deck 17ft 6in, gross tonnage 3800 tons, 1400 passengers, crew 67, speed 19½ knots. Launch, July 19th.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME and PLACE at which the meeting is to be held should be clearly stated.

Stephenson Locomotive Society

Sat., Aug. 11th.—SCOTTISH CENTRE: Visits to Motherwell and Hamilton Running Sheds, 2.30 p.m.

Sat., Aug. 18th.—Visits to Motive Power Depots (London and Southern), Stratford, (North Eastern) Gateshead, (North Western) Bolton and Bury, (Scottish) St. Margarets, 2.30 p.m.

Sun., Aug. 19th.—Visit to Swindon Locomotive Works and Running Sheds, from 1.30 p.m.

Sat., Aug. 25th.—Lineside Traffic Observation, Bromsgrove and Lickey Incline, L.M. and W. Regions, from 2 p.m.